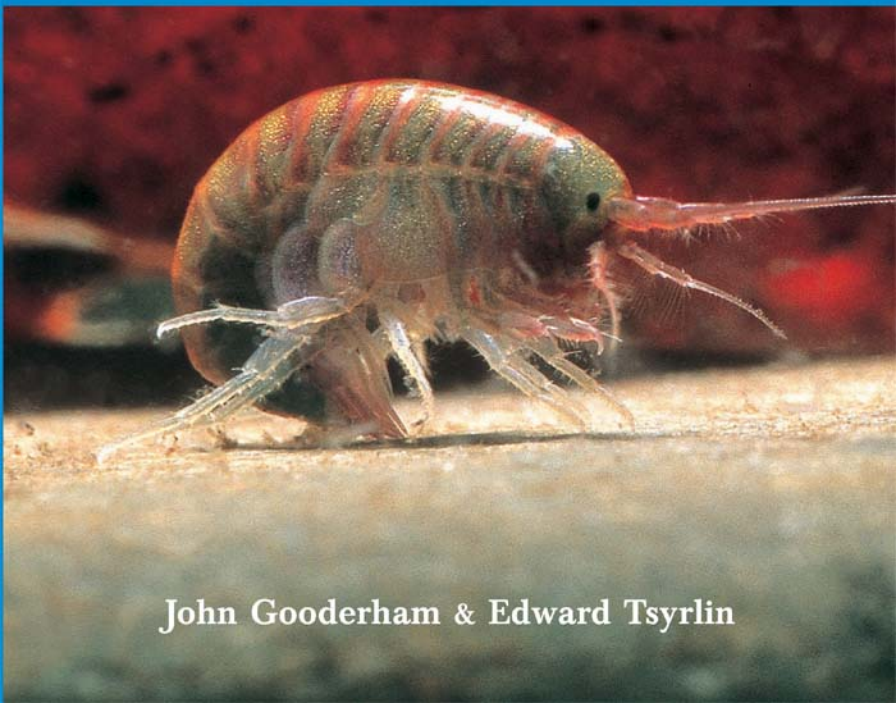
A Guide to the Freshwater Macroinvertebrates of Temperate Australia

The Waterbug Book



John Gooderham & Edward Tsyrlin

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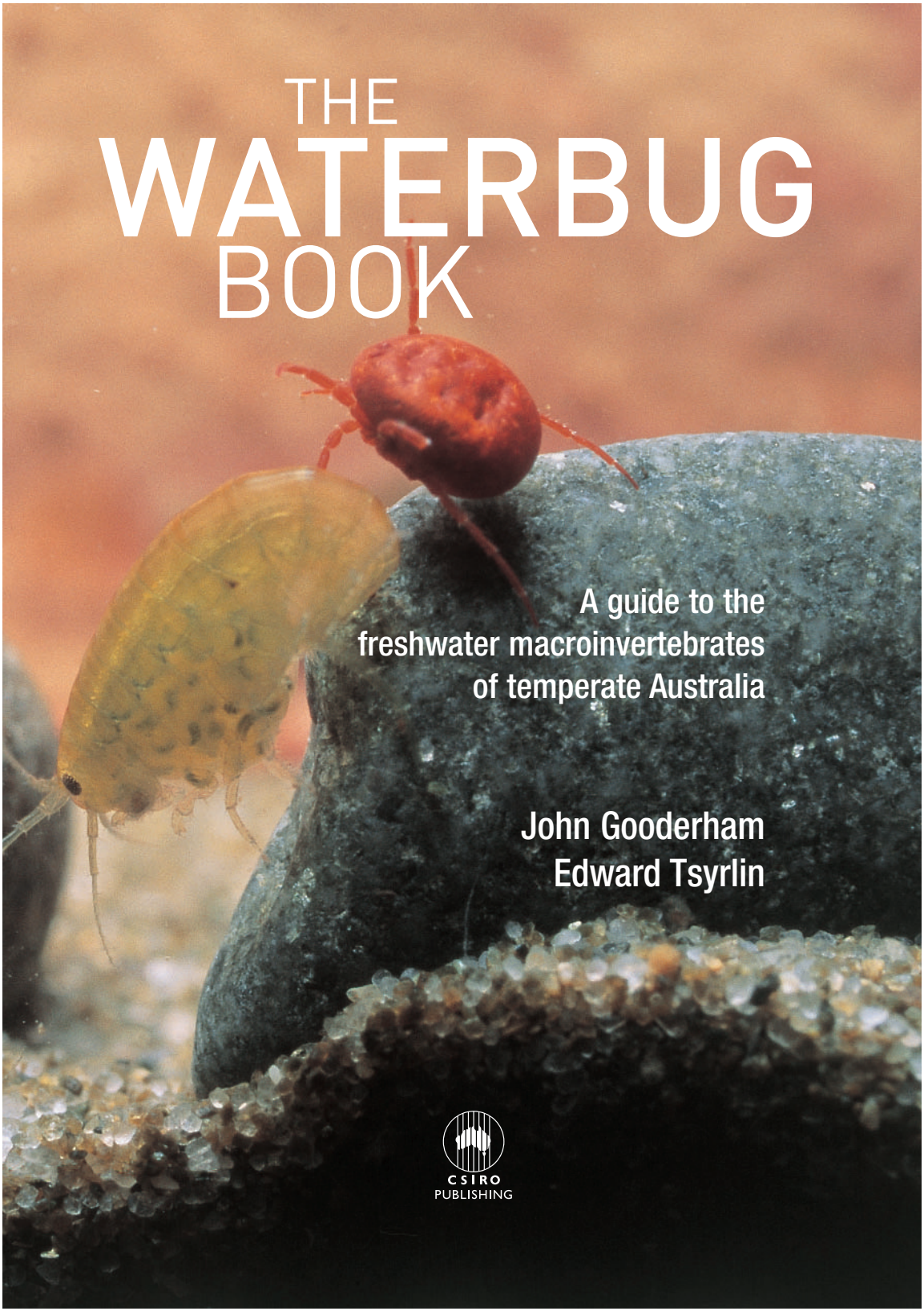

A guide to the freshwater macroinvertebrates of temperate Australia

John Gooderham
Edward Tsyrlin

CSIRO PUBLISHING

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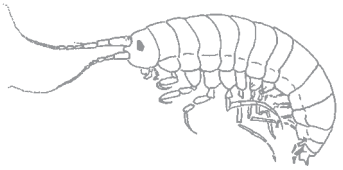

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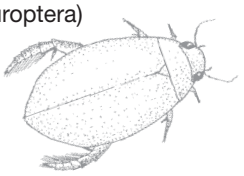


Preface

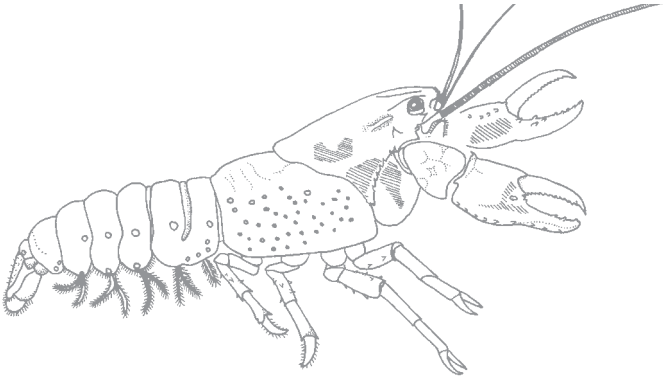
Most people are familiar with yabbies, mud eyes and water boatmen, but these are only a small sample of the 'waterbugs' that inhabit our lakes, streams, billabongs, wetlands, farm dams and even neglected swimming pools.

This book aims to introduce the often-ignored diversity of freshwater macroinvertebrates that can be found in temperate Australia. It will help amateur naturalists, fishing enthusiasts, Waterwatch members and school students to identify freshwater macroinvertebrates, while providing a rapid reference for professional stream ecologists.

The introductory chapters cover some background information about freshwater ecology and freshwater environments. The rest of the book is devoted to identifying macroinvertebrates and providing information on specific groups. Different sections contain different levels of information, so people who are learning about stream invertebrates for the first time can use the illustrated key to groups of freshwater macroinvertebrates or simply leaf through the pictures. Those with more experience can continue through to a more precise identification by following the keys included at the end of each group section.

Freshwater invertebrates can form a mini ecosystem that fits inside a classroom fish tank and provides students with dramatic examples of foodweb ecology and animal behaviour. They also provide a valuable opportunity for students and community groups to try their hand at environmental assessment.

Water management bodies such as Melbourne Water, the Environment Protection Authority, Victoria, and Hydro Tasmania commonly use stream invertebrates as biological indicators of river health in monitoring programs. While the sophisticated methods of these organisations are beyond the scope of most Waterwatch or school groups, the SIGNAL score method (see page 19), provides a reliable 'back of an envelope' method for conducting small-scale river health assessments.



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Several photographs were kindly contributed from other sources. These are specifically acknowledged in their captions, but thanks go to Brian Smith, Gen-yu Sasaki, Niall Doran, John Hawking, Karlie Hawking, John Trueman, Caroline Dearson and Kathryn Jerie. Technical photographic assistance was provided by David Humfrey, Arthur Wall and the team from Medical Illustrations at Monash University. C. Riley Nelson shared with us his secrets of bug photography. Preserved specimens were borrowed from Alena Glaister, Rhonda Butcher, DPIWE Tasmania, Water EcoScience, The Water Studies Centre (Monash University) and EPA Victoria. Most of them knew about it.

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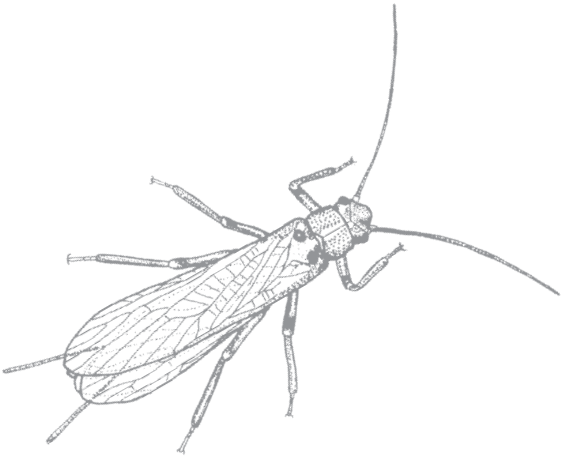
Our families have been supportive (like author's families usually are) but they have also rolled up their sleeves and helped with diagrams, editing and photography. Thank you Kathryn Jerie and Katriona Tsyrlin. Perhaps we can go away on weekends now?



Condominium Creek in Tasmania's south-west is a small, almost pristine river.

Introduction

Freshwater macroinvertebrates are a diverse group of animals, ranging from worms and leeches to crustaceans and insects. You can encounter them when fishing, hiking, or bird watching, and you don't have to study them intensively to appreciate them.

Finding freshwater invertebrates

Most freshwater macroinvertebrates are quite small but many can still be seen with the naked eye. You can find them in two main types of water: running water (*lotic* habitats) and still water (*lentic* habitats), but these can be broken up into different freshwater environments.

Springs, streams and rivers

Seeps or springs are very small trickles of water, often at the very beginning of streams where groundwater comes to the surface. Most streams can run underground for at least some of their length and many will go underground several times throughout their length depending on how permeable the rocks beneath them are. Most of the animals found in seeps are able to burrow back into the ground when flows drop and the water recedes underground. Sometimes these features can be connected to nearby cave systems.

Streams and rivers are often broken into sections of fast/turbulent flow and slow flow. The fast turbulent bits are more common in steep headwaters and are termed riffles. The slow patches between riffles are called pools if they are very slow, or runs if they are clearly flowing but fail to break the water surface up into white patches. Lowland rivers tend to be a combination of pools and runs due to their gentle slope. Riffle animals tend to live on and under rocks in the stream, where they hold onto the streambed to resist being washed downstream. In the more gentle sections of rivers, animals are more likely to be free-living and swim around in the water column. In many ways, the fauna of river pools can be quite similar to the fauna of ponds and billabongs.

Taffey's Creek in Tasmania is a blackwater stream. The colour comes from rotting vegetation or peat upstream.

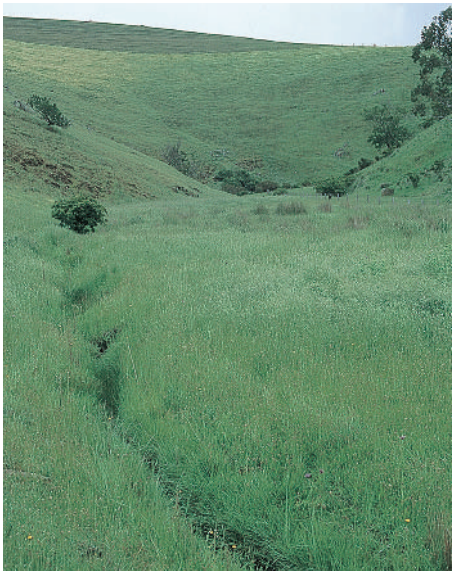
In all of these environments, areas with aquatic vegetation, leaf litter and woody debris provide habitat for a diverse range of animals. Even irrigation channels can provide a place to live for some of the more tolerant groups of freshwater macroinvertebrates.

Puddles, dams, billabongs, ponds and lakes

Billabongs are sections of river curve that have been cut off from the main channel as the river moves around on its floodplain. For this reason they often have a fauna that is halfway between the flowing rivers described above and the ponds and lakes discussed later in this section. The longer they are cut off from the river, the more pond-like their fauna will become.

Still waters with no connection to streams or rivers have a fairly simple fauna. They can only be colonised by animals that can fly to them, so they tend to be dominated by midges and other flies such as mosquitoes. Once these are established, the predators invade: bugs and beetles and the odd dragonfly. If the water stays for a reasonable length of time, other animals will find their way to it and the fauna will eventually include caddisflies and other insects.

Puddles, dams, old swimming pools and ponds will all develop in a similar way. Aquatic vegetation, leaf litter and woody debris will provide extra habitat opportunities and increase the diversity of animals found in any of these environments.



Even a small creek that cuts its way through a paddock can host a thriving waterbug community.

Lakes usually have rivers flowing into and out of them, so they often share some of the river's fauna, but they also have their own distinct fauna. Lakes offer a diverse range of depths and these support different types of aquatic plants which in turn offer different habitat opportunities for a range of different animals.

A farm dam, despite its rural settings, can be full of aquatic life. A ring of last year's rushes shows the level of the water during summer.

A billabong in northern Victoria. Sometimes this drying pool is connected to the nearby river.

Wetlands, swamps, and marshes

Most of these habitats spend some period of their time dry. This means that their inhabitants either have to re-invade the water once the dry period ends, or survive by resting in the soil. Insects tend to re-invade, but a range of specialist crustaceans exist that have small drought-tolerant eggs.

The fauna within these environments varies greatly and wetlands are some of the most diverse freshwater habitats in south-eastern Australia. These habitats also support a very diverse range of aquatic plants.

Estuaries

An estuary—a place where the river meets the sea— is usually considered a marine environment, but in their upstream sections, estuaries can have a mixture of freshwater animals that can tolerate some salt, and saltwater animals that can tolerate freshwater.

Estuaries can be difficult places to study as they are so dynamic, but this just makes them more interesting. As always, aquatic vegetation, leaf litter and woody debris will increase the diversity of animals found in these environments.

Hazelwood's Lagoon fills when the Clyde River floods — an increasingly infrequent event. It dries up to a few muddy patches over summer.

Large lakes such as Lake Seal in Tasmania can support a mixture of lake and river animals.

Catching freshwater macroinvertebrates

Pick up a stone or a piece of submerged wood in your nearest creek. Turn it over and look closely. The creatures that scatter under the thin film of water can be washed into a jar or a tray, and this will let you get a closer look at them.

If you want to look at a larger range of animals, it is best to use a net. A butterfly net is not strong enough. A good aquatic net has to have a strong handle and a flat edge so that you can get close to the bottom-dwelling animals.

If you don't have a net, an old sieve attached to a broom handle will do the job. If you put a piece of old stocking over the sieve and secure it with rubber bands it makes the mesh finer, and you can catch smaller animals.

You will also need a tray to help separate the animals from the sand, mud and debris. An old white photographic tray is ideal. Alternatively you can use a light coloured kitty litter tray.

A selection of nets. Most professional nets have flat bottoms.

Finally you will need tweezers, large-mouthed pipettes (or a turkey baster), small plastic spoons, and fine paint brushes to pick up the animals. Tweezers can often damage fragile animals so if you intend to keep your captives alive use pipettes, spoons and brushes. Large insects and crayfish can be picked up by hand. If you want to see the smaller creatures, you will need a good magnifying glass as well.

When using a net in fast-flowing water with a rocky riverbed, hold the net firmly in a vertical position against the bed with its mouth facing upstream. Lift and stir stones with your hands or a booted foot just upstream of the net. A cloud of debris and dislodged stream invertebrates will be washed into the net.

In slow or still water stir the bed and scoop up the debris or sweep the net through submerged vegetation. Many invertebrates live on submerged wood and debris.

You can brush and rinse the pieces of wood over the tray or net. Heavy logs can be scrubbed in the water while holding your net close downstream.

You will end up with a mixture of debris and macroinvertebrates in the net. To separate them, fill up a third of your white tray with water and empty the contents of the net into it. It is important not to collect too much in one go so that the amount of debris does not cover more than half the area of the tray. Now get comfortable, and sort slowly through the tray, moving all the animals you find to a separate container or an ice cube tray so that you can look at them later. Professional stream ecologists call this process 'bug-picking'. A magnifying glass and a smaller container or jar will come in handy if you want to observe live animals in the field, but your observations don't have to stop when you go home. You can set up a fish tank at home and as long as you keep it aerated and only keep animals from slow-flowing or still water, it will be easy to maintain. It is difficult to believe, but even urban creeks have enough creatures to fill up your fish tank with aquatic life.

Bug-picking tools include an ice cube tray for holding waterbugs, a plastic spoon, tweezers, a pipette and two different magnifying glasses.

The Huon Valley Waterwatch group practising their sampling technique on the Mountain River.

Preservation and labelling

You can identify the invertebrates you find using this book in the field, or you can preserve them for identification later. Professional stream ecologists use 70% ethanol to preserve their animals. This can be expensive, but a mixture of 75% methylated spirits with 25% water works almost as well. If you think you have found unusual or interesting animals contact your local naturalist club, Waterwatch group or state museum. However, to make your information valuable try to put only one group of invertebrates in a vial or jar and clearly label it. (Soft pencil on thick paper will not rub off.) Include information about the exact location, such as the name of the river or pond and the name of the nearest geographical feature such as a road, township, bridge etc. Also include the date and the name of the person who collected the specimen, as this will allow scientists to find you if they need to ask more questions.

Never take more animals than you need and return the leftovers to the place where you found them.

Introducing freshwater ecology

Whether you step into a puddle or a river, you are entering a world which is every bit as complex as the large terrestrial ecosystems we are more familiar with. Thanks to David Attenborough, most people are familiar with the ecology of the Serengeti Plains in Africa even if they have spent their entire lives in Sydney. In the Serengeti, hordes of herbivores (wildebeest and zebra) roam the grasslands, grazing on plants, while a smaller number of predators (lions and hyenas) kill and eat them. The vultures and carrion beetles that help themselves to the lion's dinner add layers to a structure which ecologists have named the foodweb.

The foodweb is a concept that explains how different organisms within an ecosystem

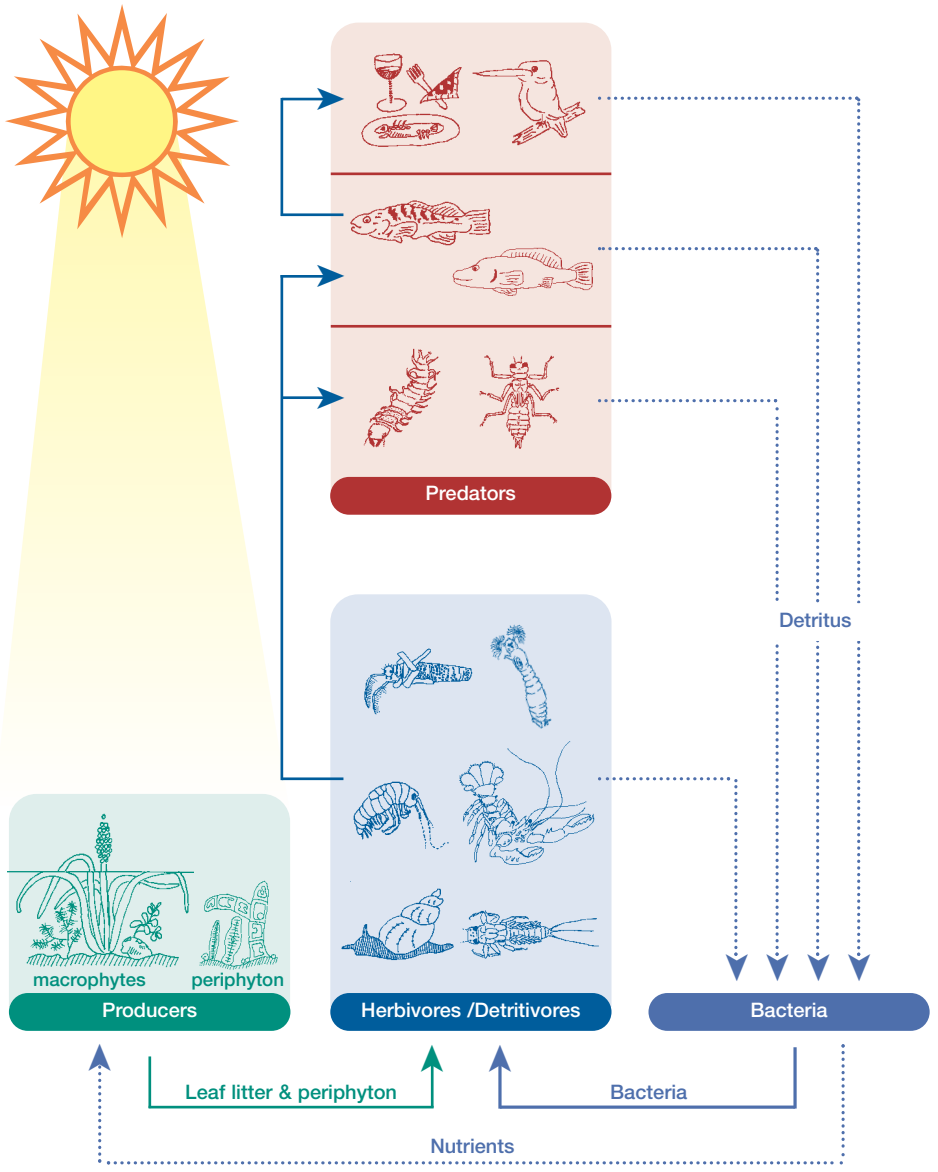


Figure 1. A 'foodweb' depicts the flow of energy or nutrients, starting with the sun in the top left. The pattern is fairly circular, with the detritus from herbivores, detritivores and predators ultimately providing nutrients for the producers. In the real world, things are a lot more complicated than this.

feed upon one another. Figure 1 shows a highly simplified foodweb from a stream. The various levels in the foodweb correspond to the various ecological 'jobs' within an ecosystem, while the arrows show the movement of food between organisms within the system. Similar jobs exist in ponds, rivers, and on the Serengeti Plains. The animals that occupy these positions will be different in each system—for example lions and dragonfly larvae—even though their function can be much the same.

Job description: producers

At the bottom of the foodweb are organisms such as algae, plants and bacteria which create their own energy from sunlight and/or raw chemicals that are available directly from their surroundings. These are called **producers**, as they take resources that other organisms cannot readily use, and produce energy in a form that can be readily used by organisms higher up the foodweb. Unfortunately for them, this usually involves being eaten. In stream environments, the three dominant forms of producers are: ordinary plants whose leaves fall into the water, aquatic plants or macrophytes (from the Greek, *macro* = large, *phyton* = plants), and periphyton (*peri* = edge, *phyton* = plants), which is a thin, slippery layer of algae and bacteria which coats stones and other surfaces in streams.

Job description: herbivores

Herbivores occupy the next level up on the foodweb. They eat **producers**. The two basic types of herbivores present in streams are described by the way they eat. **Scrapers** graze periphyton, scraping the thin layer of algae from rocks and other hard surfaces. This group includes many aquatic snails together with a variety of other invertebrates equipped with brushes or blades on their mouthparts for removing the firmly attached algal layer. **Shredders** can sometimes eat macrophytes, by chewing through leaves or boring into the stems of the plants, but most consume old, dead, rotting plant material or detritus. This makes them **detritivores** as well as **herbivores**.

Even the largest predators are prey for fish and birds. Most dragonfly larvae spend half their lives hunting and the other half being hunted.

Job description: predators

Predators are generally larger invertebrates, such as dragonfly larvae (Odonata) and dobsonfly larvae (Megaloptera) and larger animals such as fish, frogs, and birds. They get their energy by devouring other animals. Their victims can be **herbivores**, **detritivores** or other **predators**.

Job description: detritivores

Detritivores eat a mixture of leaf litter, woody debris, and the bodies of dead organisms. When organic matter first enters the stream it tends to be large and chunky (see Figure 2).

The **detritivores** that deal with coarse debris are **shredders**. They break it down into

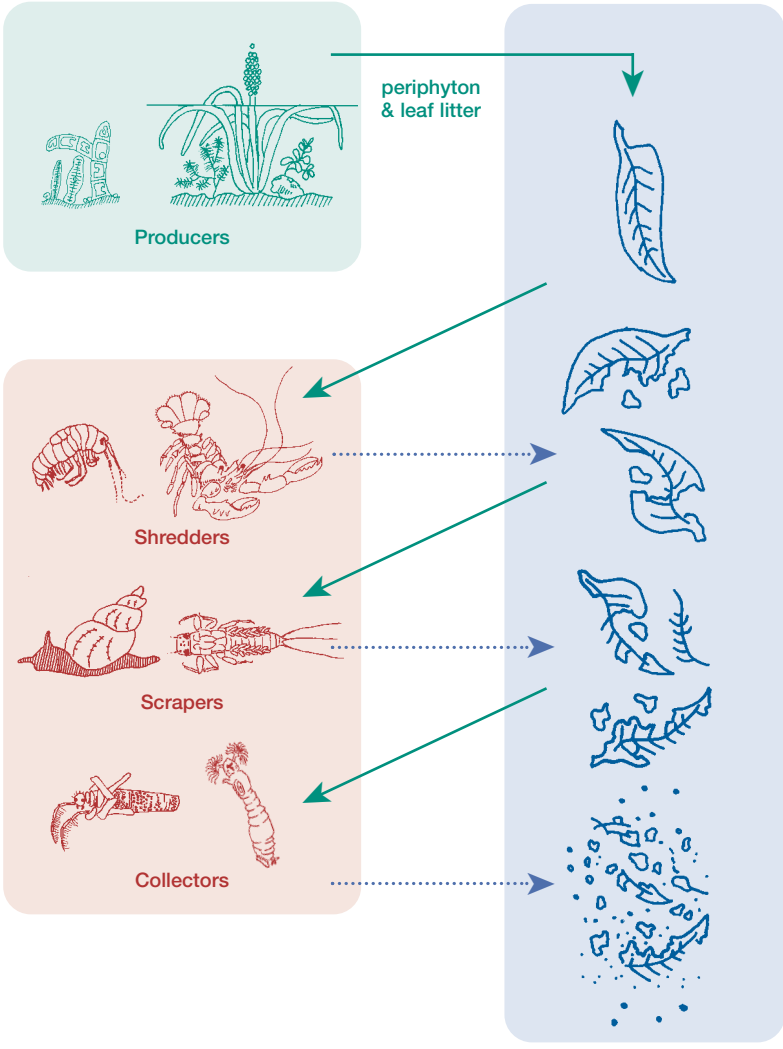


Figure 2. Animals break down leaf litter and other organic matter. Different animals use leaf litter in different ways, depending on how broken up it is and how much periphyton it has growing on it.

smaller pieces, while extracting what nutrients they can from a combination of the old plant matter itself and the bacteria and fungi that grow on it.

Many **detritivores** are also **herbivores** because the mouthparts and digestive systems needed to eat live or dead plant material are so similar. Animals such as yabbies (Parastacidae) will eat just about anything: animal or plant, living or dead.

As organic matter moves downstream, it is chewed and digested into smaller and

smaller pieces, until it becomes a cloud of particles. The **detritivores** that utilise this form of organic matter are **collectors** (or **filter feeders**). Many of these have specialised hairs on their legs or around their mouthparts which strain the fine organics from the water as it flows past them. Some examples of **collectors** include black fly larvae (Simuliidae), and some stick-dwelling caddisflies (Leptoceridae).

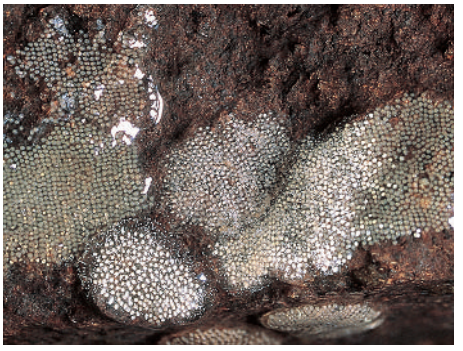
Foodweb loops

While organic matter is broken down by **detritivores**, its smaller, basic components are released back into the water in the form of nutrients (various states of carbon, nitrogen and phosphorous) where they are used by **producers**, thus completing one of the loops of the foodweb. The waste products of **predators** also find their way back to the base of the foodweb where they are used by **producers**.

Lifecycles

Most invertebrates follow a simple lifecycle. They hatch from eggs and spend some time developing. Once the larvae or nymphs have grown, they become adults, reproduce sexually and lay eggs from which young emerge to start the cycle again. However, some invertebrates employ more interesting methods of reproduction, such as fission and hermaphroditism. Fission is used by animals such as turbellarian flatworms, sponges (Porifera) and hydra (Cnidaria). They can split into multiple individuals voluntarily, or can recover from being cut up by predators or scientists. Each separate piece becomes an individual animal.

Hermaphrodite reproduction is used by some snails (Gastropoda) and leeches (Hirudinea). Individuals have both male and female organs so that each of the partners can lay fertilised eggs.



Most freshwater macroinvertebrates start life as eggs. The eggs on the underside of this stream cobble are surrounded by a thick protective layer of jelly.

The male giant water bug (Belostomatidae) has his back covered with eggs by the female. This keeps them safe from predators and dad can't reach them either.

Growth

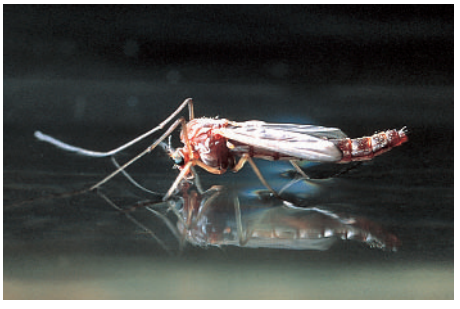
All invertebrates grow, but they vary greatly in the way that they do it. Leeches and snails have skins that can grow at the same rate as the rest of the animal. They simply get bigger as we do. Crustaceans and insects (Phylum Arthropoda) have external skeletons, and these don't grow much once they have hardened. To avoid being compressed inside their own skins, arthropods frequently shed their skins, replacing the old ones with the next size up. Some arthropods can have as many as 50 skins in a lifetime.

Many of the invertebrates in streams are insects. During the course of their lives they change from a young wingless insect into a fully winged adult. There are two ways that this amazing change can happen: the larval lifecycle or the nymphal lifecycle.

Larvae have soft, simple bodies when they are young and usually look nothing like their parents. They are sometimes such simplified eating machines that they even lack legs. When larvae reach a size that will convert nicely into a healthy adult insect, they enter a 'pupal' phase. During this phase they transform themselves into winged adults.

The **pupa** is a deceptively simple shell inside which the insect is rebuilding itself in adult form. Adults can emerge from the pupal skin while it is submerged, or in some cases

Larval lifecycle



The chironomid larva (*Chironomus* sp.) has a simple body. It goes through a pupal phase in order to turn itself into a winged adult.

Nymphal lifecycle

The waterboatman nymph changes gradually as it grows until its wings are large enough to use.

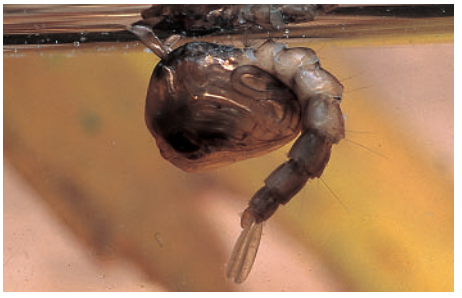
the pupa can move and swim to the surface where the adult struggles from the split pupal skin.

Nymphs generally resemble their parents quite closely, and simply lack the adult's wings and size. Small nymphs start with wing buds which grow with the animal, to eventually become fully developed wings.

Some nymphs leave the water when they become adults. The nymph crawls out of

Different types of pupae

A mobile caddis pupa swims to the surface to emerge. The swimming hairs on some of its legs help to push it through the water.

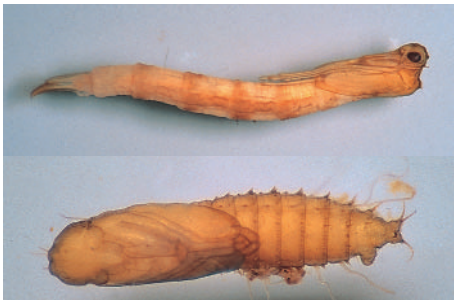


A mosquito pupa (Culicidae) has breathing horns that puncture the water surface and replenish the pupa's air supply.

A hydrobiosid caddisfly encased in its fine silk pupal sheath is protected by a layer of fine gravel and is stuck to the underside of a rock.

The black fly pupa constructs a harness that keeps it from being washed away by the current.

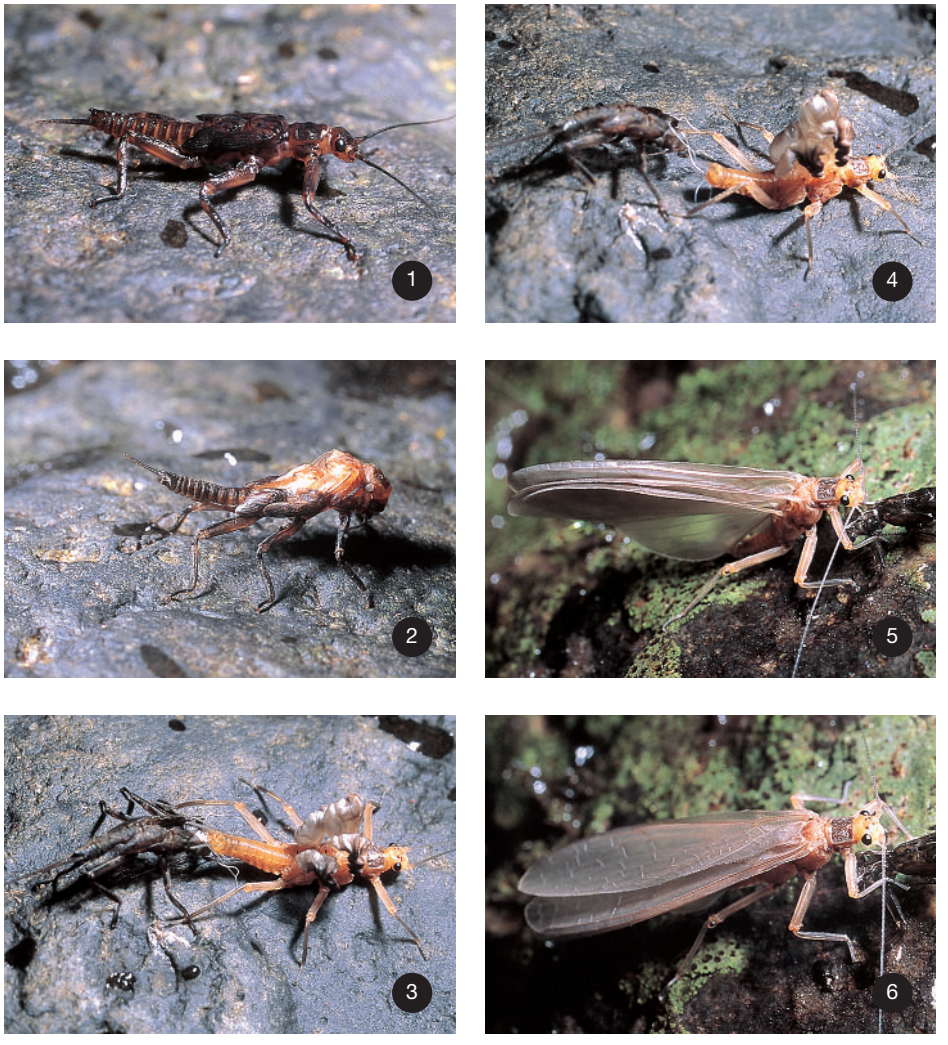
Conoesucid caddisflies pupate inside their cases after sealing the ends with a silk disc.



A tipulid pupa (top) and an empidid pupa show how fly pupae vary greatly in shape.

the water, splits down the back, and steps out of its skin. The emerging insect is already fitted with a pair of wings, which it then inflates with 'blood'. The new wings are very soft at first and must harden before the animal can use them to fly. This can take about an hour. During this time their bodies are soft too and they are vulnerable to predators.

Some insects such as true bugs and beetles will return to the water to live as adults, while others cannot and will only venture back to lay eggs and die.



The stonefly nymph (*Trinotoperla minor)* crawls from the water (top left) and begins its strenuous change into a winged adult.

Waterbugs and us—from feasting to fly tying

People notice things quickly if they are painful, uncomfortable or annoying. Freshwater macroinvertebrates can be all three and it is likely that this is how humans first noticed them. Even today, we know a lot more about the insects that bite, blind and infect us with diseases than we do about their less troublesome relatives.

Some of the most painful freshwater macroinvertebrates are true flies or Diptera. Members of this group include mosquitoes (Culicidae), black flies (Simuliidae), biting midges (Ceratopogonidae) and horse flies (Tabanidae), all animals that are known for their bites. Medical entomology was in many ways one of the more applied beginnings of freshwater ecology. Controlling these species involved learning about their ecology and biology. As noted by H.B.N. Hynes in his essay on 'aquatic insects and mankind' many of the problems with these animals stem directly from our modification of their original habitat. Mild organic pollution can benefit the larval stages of many of the more tolerant aquatic fly larvae, and humans and livestock provide plenty of opportunities for the blood-sucking adults. As a result, many of the wetlands and streams in rural and urban areas offer prime conditions for a lot of these species to become pests.

Biting back

Freshwater invertebrates might be noticeable when swarms of them are eating us but in some parts of the world humans get the better of invertebrates and dine on them instead. Singly, few invertebrates offer enough muscle to be a meal, but when they swarm, insects can occur in large enough volume to be an important source of food. David Livingstone, the famous explorer, encountered a form of cuisine on the banks of Lake Malawi (Nyasa) in Africa, which involved collecting large quantities of phantom midges (*Chaoborus edulis*), boiling them and forming them into patties. The end product was said to taste a little like caviar. In Mexico, two species of water-boatmen (*Corisella edulis*, *C. mercenaria*) suffer a similar fate. Their names reflect their edibility and their market value (as dried goods) respectively.

The North American Indians are also thought to have taken advantage of flies from the families Athericidae and Ephydridae. These were harvested as they gathered on streamside vegetation to lay eggs and baked into small cakes and stored as winter provisions. In Rawa Lamongan, Indonesia, one of the local dishes provides an example of individual invertebrates that are large enough to be eaten singly. Large water beetles (Dytiscidae) are trussed up with grass stems and grilled in a fire. The hard shell acts as a bowl and the animal is eaten a bit like an oyster once the wing covers have been removed. Westerners are perhaps a little more comfortable eating crustaceans such as yabbies, freshwater prawns and shrimp. In southern Vietnam, one of the more novel crustacean dishes involves freshwater shrimp in a cold, clear soup. This simple dish rates a mention as the shrimp are served alive and have to be pursued around the bowl. 'Dancing shrimp soup' is not a dish for hungry or impatient people.

Most aquatic invertebrates are edible. Exceptions include freshwater mites, flatworms and some of the waterbugs, as these animals have pores in their skin which exude foul-tasting or toxic substances. The taste of most invertebrates is often much subtler than their texture and few Western people can stomach the combination of crunchy, leathery outsides and liquid insides. We have tried blind tasting caddisfly adults to see if different families could be separated based on their taste.

A selection of fishing flies.

We found that they couldn't, but that the leptocerids with their long wings and antennae were a choking hazard. This must be why winged insects are usually singed over a fire before they are eaten.

Lures and flies

Western society often shuns the eating of macroinvertebrates but is partial to fish, particularly the large predatory species such as cod, bass, perch and the introduced trout and salmon. Macroinvertebrates make up the main diet of most freshwater fish, and for this reason they dominate the bait used when fishing, either as live baits or as replicas such as lures or flies. Knowing a little bit about the ecology and life history of freshwater macroinvertebrates has allowed us to refine the sports of lure and fly fishing.

The earliest use of lures or flies is thought to date back to the twelfth century in Europe. These originally crude lures were simply wool or feather-covered hooks, but they developed until they became the intricately assembled flies described by Izaak Walton in his famous seventeenth-century text *The Compleat Angler*. Flies are constructed primarily from fur and feathers tied and twisted to resemble almost every imaginable macroinvertebrate (with the exception of flatworms). Flies can even be constructed to imitate the various life stages of different animals. A good example of this can be found with the angler's favourite stream insect: the mayfly. Wet flies are heavy enough to sink and this allows them to mimic the aquatic nymphs of mayflies, dry flies rest on the surface, tempting the trout with the image of a mayfly struggling free from its nymphal skin and trying to come to terms with flight. Different dry flies can be made to represent emerging mayflies, females laying eggs by dipping their abdomens in the water, or spent mayflies, exhausted by their reproductive efforts and flopping spent against the surface of the water.

Two concepts are used to make a fly work (or blamed for its failure). The first is the accuracy of the imitation and the second is the timing of the fly presentation.
A successful fly is taken by a fish because it looks like a real macroinvertebrate.
The theory goes that a fly that lands on the water, by itself, is considered as an individual and therefore scrutinised more heavily by a fish. A fly that lands on the water during a swarm of food that the fish are currently eating is taken because it is already recognised by the fish as food.
For this reason, fly fishing has developed around 'matching the hatch'. This involves using a fly that resembles the original invertebrates or 'naturals', but also using the right fly at the right time. Finding out this sort of information has forged a strong link between anglers and freshwater scientists. The angler's obsession with some of these invertebrates has given birth to some interesting biological studies and alternately, fly fishing has allowed a number of eminent entomologists to mix their work and play.

This fishing fly (left) is weighted so that it sinks and moves under water like the nymph of the mayfly *Coloburiscoides* that it imitates (right).

This fishing fly (left) copies the pose of a spent mayfly (right), lying with its wings flat against the surface of the water.

The hairs of this fly (left) don't imitate the legs of an adult caddisfly exactly but they bend the surface of the water in a similar way and stop the hook from sinking.

Some flies can be very small. This pair (left) imitates a chironomid, or non-biting midge, and its pupa (right). They are less than a centimetre long.

Studying freshwater macroinvertebrates

People have, at times, been interested in freshwater invertebrates simply because they are fascinating to study. One of the first documents written about freshwater macroinvertebrates in any detail, was penned by a Scottish doctor by the name of Thomas Moufet in 1634. In his text *Insectorum sive minimorum animalium theatrum* (roughly translates as: Insects or small animals on show), he wrote about the natural history of insects including the water scorpion (*Nepa* sp.) and the stream caddisflies of Scotland. He is possibly best known through his daughter, the original Miss Muffet (an anglicised version of Moufet) who features along with one of her father's specimens in the famous nursery rhyme.

Over the next two hundred years, the study of invertebrates was pursued by scientists from around the world and an impressive body of knowledge took shape. Freshwater invertebrates often feature in these early works as they were easy to find and keep in captivity. One of the first books written in English to concentrate on freshwater macroinvertebrates was written in 1895 and it was simply titled 'The natural history of aquatic insects' by its author L. C. Miall. In it he summarises his own work along with the studies of other people from the first 200 years of research into what was becoming a popular branch of natural history.

From fairly simple beginnings, the study of freshwater macroinvertebrates has diversified and changed focus throughout its history. As mentioned earlier, medical entomology provided some of the first studies in this field. Australia was not far behind the rest of the world, with the first official descriptions of its mosquito fauna being put to paper as early as 1835 by a fellow named Westwood, publishing in the annals of the French Entomological Society. Soon, the study of Australia's freshwater macroinvertebrates was well under way. Understandably the first animals to be studied were large animals like the water beetles, which were catalogued by Clark as early as 1862 and revised in 1882 by Sharp, along with the whirligig beetles. Other macroinvertebrate groups didn't lag far behind. In the early 1900s Goddard described a range of leeches and worms, while Sayce, Thomson and Smith turned their attention to some of the scuds or amphipods and the more primitive crustaceans of south-eastern Australia.

One of the most prolific contributors to this early bloom of freshwater science, was R. J. Tillyard who, in 1917, published a large tome titled 'The biology of dragonflies'. Tillyard went on to become the Chief of CSIRO's Division of Economic Entomology and published extensively on the mayflies, caddisflies and stoneflies of south-eastern Australia.

Freshwater macroinvertebrates are still studied extensively in Australia though these days the research has diversified. Natural history and taxonomic studies are less prevalent and the emphasis is often on river health (see page 19) or ecology, which involves studying how different species interact with one another and their surroundings.

Finding your way around macroinvertebrates

Taxonomists are the people who decide which animals are different enough to be considered species and given their own names. To do this they have developed a large amount of technical language, or jargon, which they use to describe the parts of an animal's body with great accuracy.

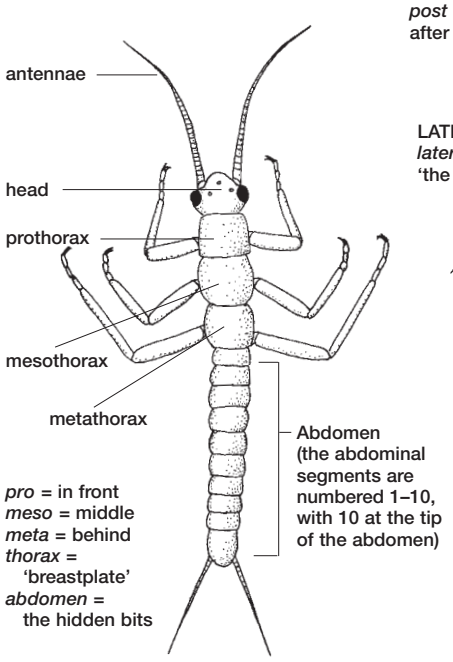


Figure 3. The basic system of naming invertebrate body parts.

This also allows them to describe the differences between species more accurately. Rather than saying 'the front part of the main section of the body', taxonomists have a single word that contains all of this information: prothorax. 'Pro' is ancient Greek for front, and 'thorax' is an ancient Greek word that originally referred to the piece of armour known as the breast plate but is now used for the part of the body between the head and the abdomen. Many taxonomic terms are put together from a mixture of ancient Greek and Latin, a reminder of the origins of much of our science. Figure 3 gives some of the commoner body parts that are used when keying out insects and other stream invertebrates.

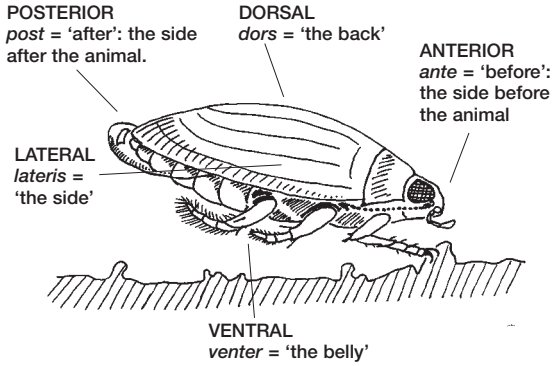


Figure 4. The basic system for describing directions and locating invertebrate body parts.

Taxonomists also have a set of words that give directions, a bit like the nautical terms port and starboard used by sailors. If a taxonomist was to refer to 'the top of the front part of the main section of the body', they would say 'dorsal prothorax'. Figure 4 demonstrates some of the direction jargon that is used. These words are easier to remember and also make more sense once they have been roughly translated, so we have provided rough translations wherever possible.

Taxonomic names: a system for classifying animals

Taxonomic names consist of a genus name and a species name, for example *Homo* (genus) *sapiens* (species). They identify animals as individual species, but they also give clues about which other species they are similar to. Species from the same genus are usually very similar. Classification is a system that allows different groups of animals and plants to be separated from one another based on consistent differences in shape. For example, mayflies and stoneflies are so different that they belong to different Orders (Ephemeroptera and Plecoptera), but are similar enough to come from the same Class (Insecta).

Table 1. Classifications of two common animals

Kingdom	Animalia	Animalia
Phylum	Arthropoda	Chordata
Class	Insecta	Mammalia
Order	Odonata	Primata
Family	Aeshnidae	Hominidae
Genus	*Austroaeschna*	*Homo*
Species	*unicornis unicornis*	*sapiens*
Common name	mudeye (a dragonfly larva)	humans

The examples in Table 1 are well known animals. Their classification reads down the page and shows that they are from the same kingdom but different phyla. Note the use of capital letters for every level except species and the different endings on each of the level names. This convention allows scientists to recognise different classification levels, when they appear in written text.

Classification groups exist at a range of levels. This book deals mainly with the **bold** levels, especially the Family level. Family names start with a capital letter and end in 'ae'. When they are referred to as common names, the 'ae' and the capital letter are dropped. Thus animals from the family Aeshnidae are referred to as aeshnids.

Why do taxonomic names change?

Sometimes the taxonomic names in this book will be different to those in older books (and newer ones eventually). Often this is because the species, genus or family name has changed. There are a number of reasons why this could happen, but the most common is that taxonomists have changed the way that they think the group of animals is related to other similar animals.

If animals that were once thought to be different are found to be quite similar, the more recently named animal takes the older animal's name. If animals have been separated, then one or both will receive new names.

Figure 5 shows how the mayfly, now called *Nousia parva* from Armidale, New South Wales, has had its name altered by taxonomy that existed before it was even discovered.

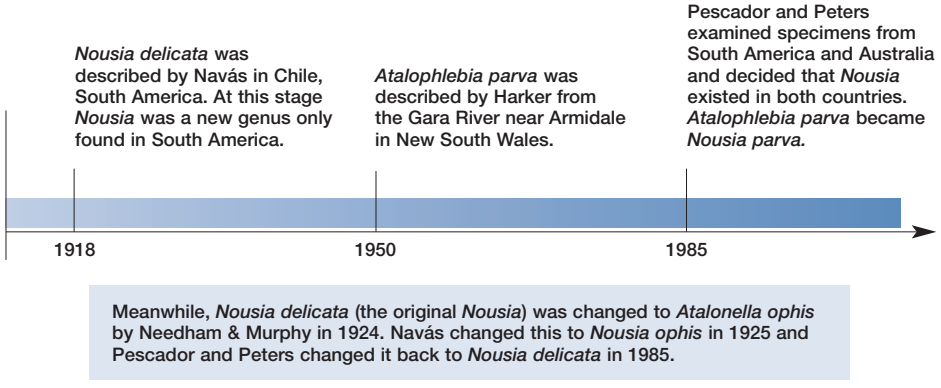


Figure 5. The mayfly *Nousia parva* is an example of the way taxonomic names can change.

Measuring water quality with the SIGNAL method

One very good reason for studying waterbugs is that they can be useful indicators of the ecological health of freshwater habitats. Scientists have found that some macro-invertebrates are more tolerant to pollution than others. If a stream is polluted, tolerant bugs will usually be found in larger numbers than intolerant ones.

On the other hand, if a habitat is close to its pristine or natural condition, tolerant types of bugs will be found alongside equal or greater numbers of more sensitive ones.

The SIGNAL method uses these ecological patterns to measure water quality using waterbugs. SIGNAL stands for **S**tream **I**nvertebrate **G**rade **N**umber – **A**verage **L**evel. By knowing the SIGNAL grade for every family, scientists can calculate the SIGNAL score of a site and therefore form an objective opinion about its health.

Calculating a SIGNAL score for your site

Step 1. Make a list of the families you find at your site and look up their SIGNAL grades on pages 213–214. For example:

Eustheniidae	10
Orthocladiinae	4
Psephenidae	6

The higher grades are given to more sensitive families and the lower grades to more tolerant families. The highest grade is 10 for sensitive families and the lowest grade is 1.

Step 2. Calculate the sum of individual SIGNAL grades: 10+4+6 =20

Step 3. Divide the sum by the number of different families you collected. We collected 3 families, therefore 20/3 = 6.7

6.7 is the SIGNAL score for your site.

SIGNAL score and water health

The following table provides a guide for interpreting water health according to the SIGNAL score of a site.

higher than 6:	healthy habitat
between 5 and 6:	mild pollution
between 4 and 5:	moderate pollution
less than 4:	severe pollution

Our site scored 6.7 and therefore can be considered a site with clean water.

If you can only identify your waterbugs as far as the order level, you can still use the SIGNAL score. Orders consist of many different families, with a variety of SIGNAL grades, so an assessment will be much more accurate with family level identification.

SIGNAL assessment is usually performed on a single sample from either a pool/edge, or a riffle and this keeps the method consistent and allows people to compare sites.

This method of assessing water health is sometimes used by scientists and professional biologists. However, its accuracy depends on how well you conducted your sampling and identification.

The SIGNAL method was originally developed on very 'normal' streams and rivers and will not work as well for freshwater habitats such as wetlands or lakes, or streams with strange (but natural) water chemistry.

If you are interested in this type of investigation and need some help, your local Waterwatch group should be able to point you in the right direction. Ring your local council to find out about Waterwatch or look them up on the internet.

Key to macroinvertebrate groups

Keys are designed to separate animals into groups and identify them. There are two types of key used in this book. The main key to groups on the following pages works like a flow chart with illustrations, and will help you find the right chapter. Within these chapters, the keys are more conventional. They are made up of pairs of opposing statements or couplets. Each couplet is numbered. The two statements within the couplet describe different sets of features. To use the key, start with the first couplet, and choose the statement that best describes the animal you want to identify, then follow the directions at the end of that statement to get to the next relevant couplet. Each choice narrows down the number of possibilities, until you are left with a single name. If everything works, this is the name of your animal. The numbers in brackets refer to the previous couplet. They allow you to retrace your steps if you get lost, or if you have second thoughts about a choice. The key below is a simple example to give you a feel for how they work. Choose any shape you like and pretend that this is the animal you are trying to identify. Now work through the couplets and try to identify it.

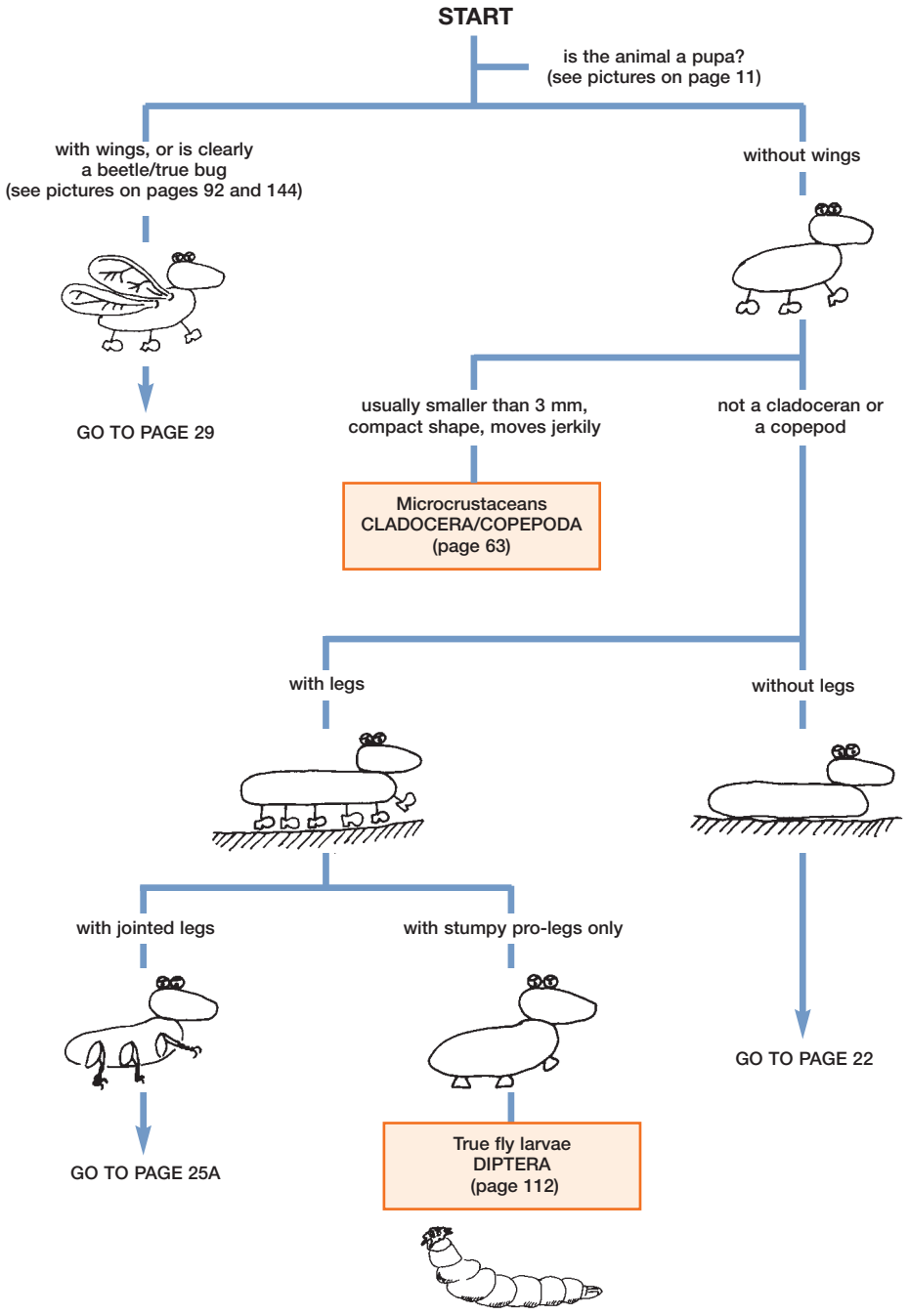
If the key doesn't seem to work for your animal, browse through the photographs until you find a match and try working backwards. If it still doesn't work, it is possible that you have a land invertebrate that has been washed into the water. To check this, you can use one of the general invertebrate references listed in the bibliography.

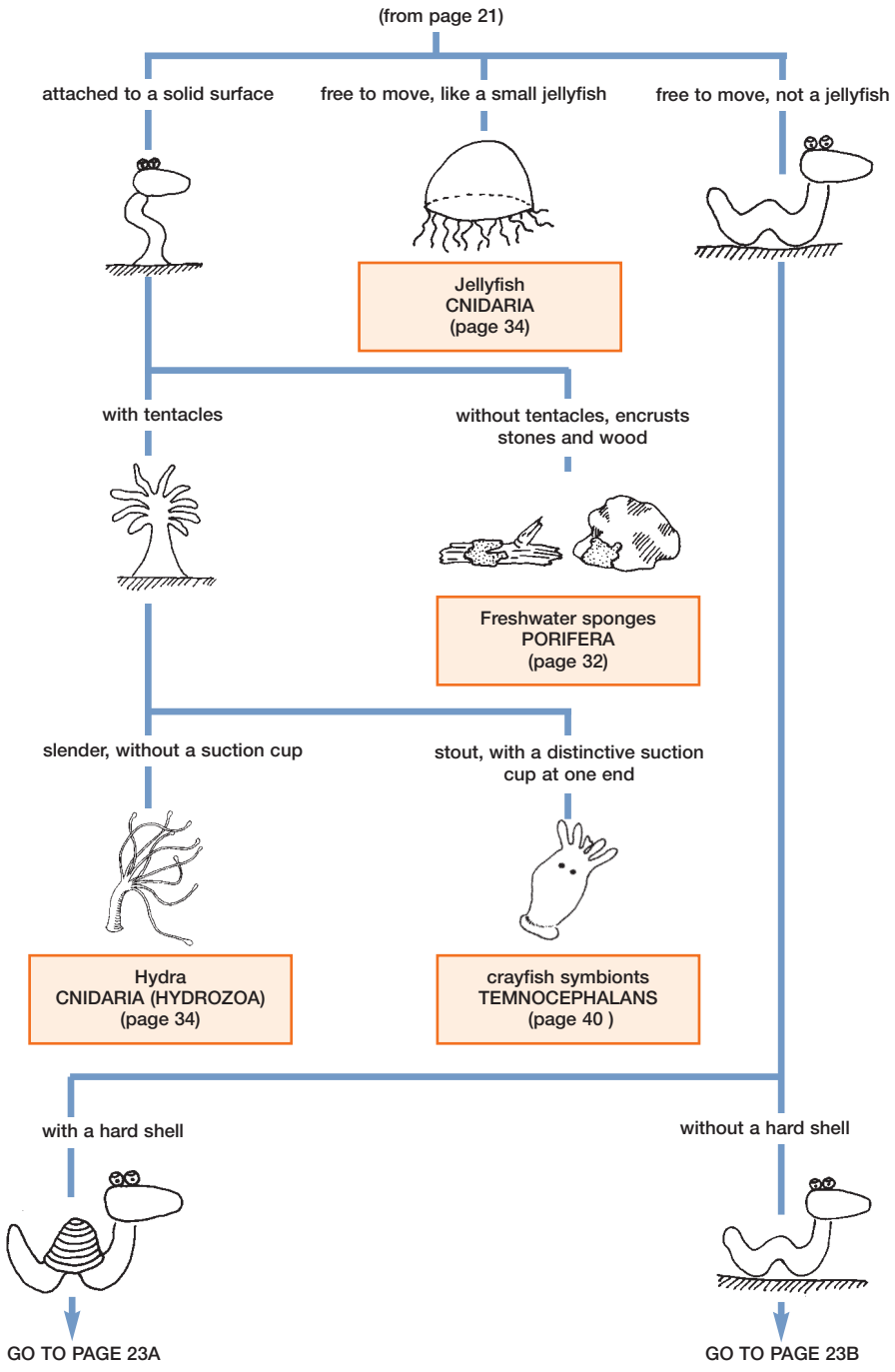
There are a few things to bear in mind before you start using a key. Macroinvertebrates are quite small, and you will need to be able to see the parts of the animal the key refers to, so if possible:

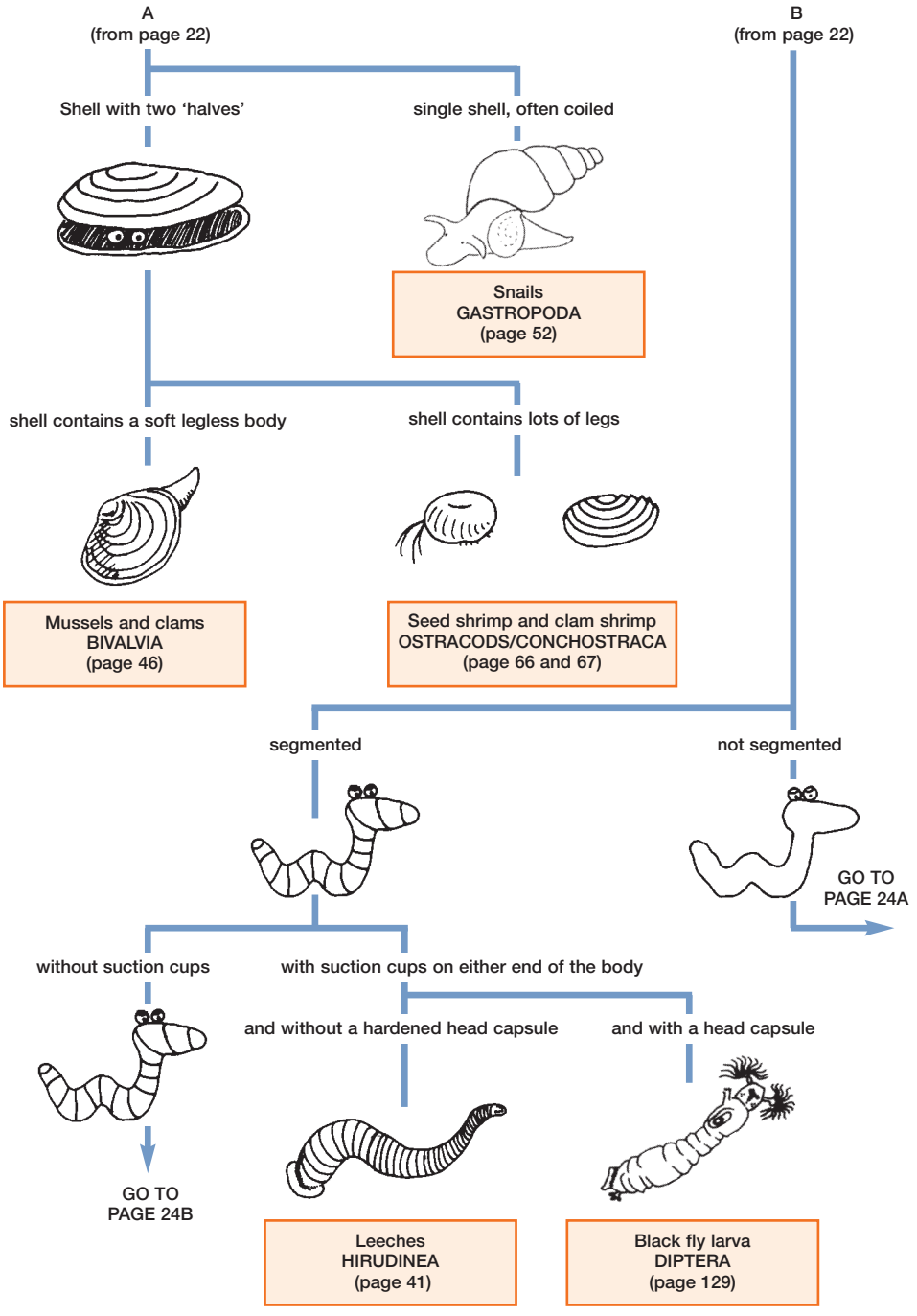
- use large examples of the animals you want to identify,
- use a good quality magnifying glass (5–10 x magnification),
- place your specimen in shallow water, it won't distort your view,
- use a clean white background (or black if it's a light coloured animal), and
- make sure you have plenty of light.

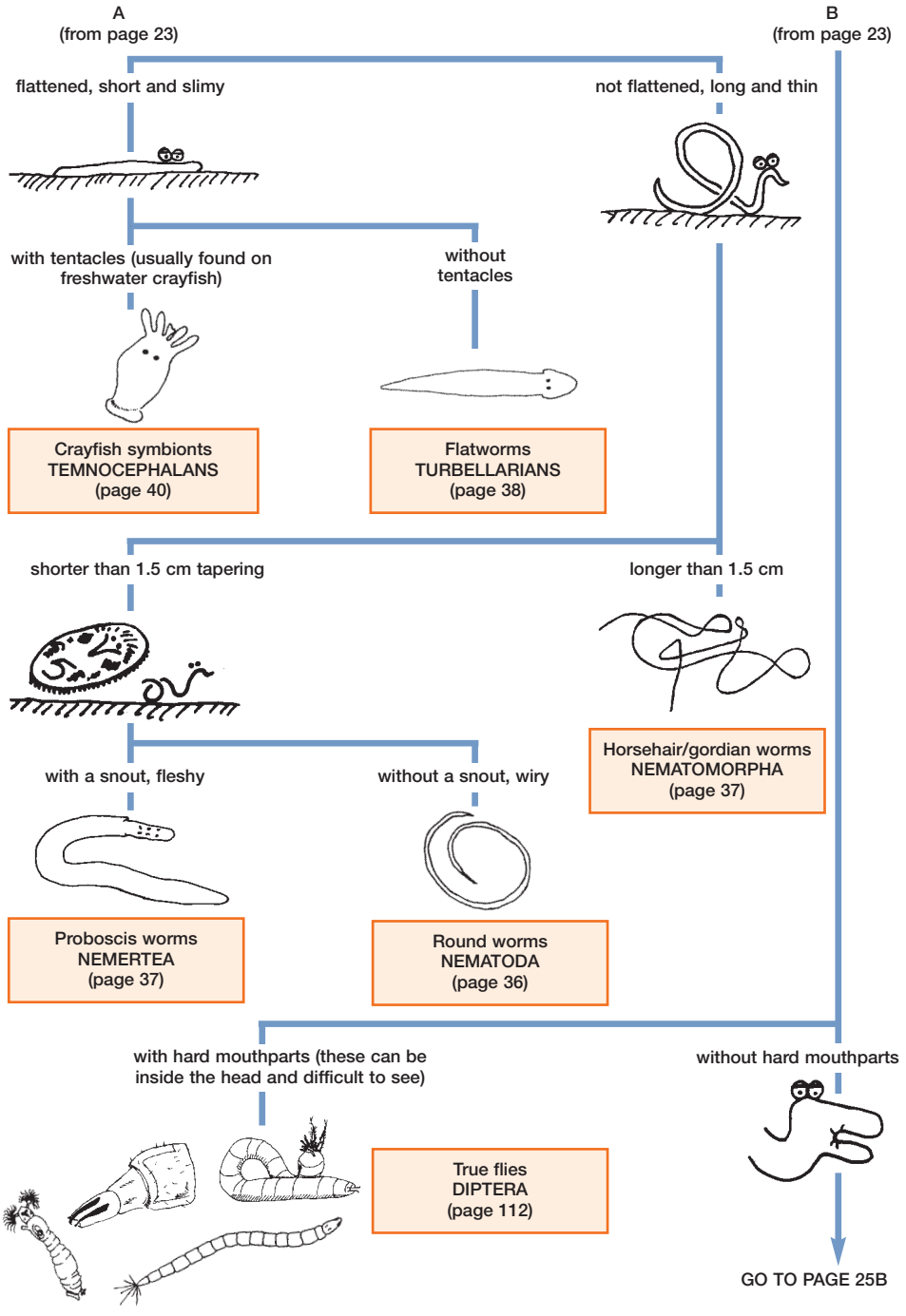
A key to shapes

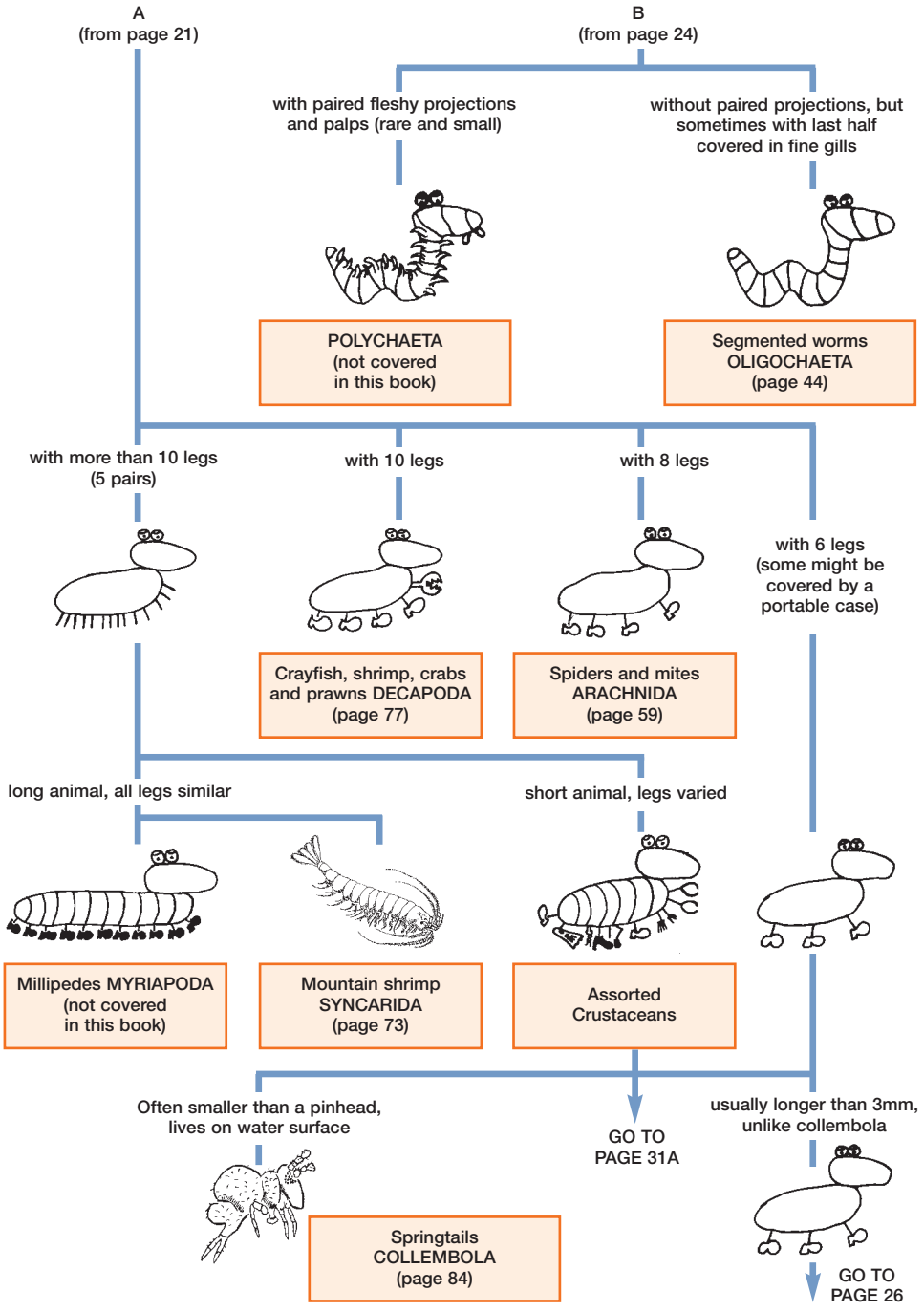
1	Sides straight	**3** (go to line 3, missing line 2)
	Sides curved	**2** (go to line 2)
2(1)	Length and width the same	**CIRCLE**
	Length and width different	**OVAL**
3(1)	Three sides	**TRIANGLE**
	Four sides	**4**
4(3)	Length and width the same	**SQUARE**
	Length and width different	**RECTANGLE**


START
is the animal a pupa?
(see pictures on page 11)
with wings, or is clearly
a beetle/true bug
(see pictures on pages 92 and 144)
without wings
GO TO PAGE 29
usually smaller than 3 mm,
compact shape, moves jerkily
not a cladoceran or
a copepod
Microcrustaceans
CLADOCERA/COPEPODA
(page 63)
with legs
without legs
with jointed legs
with stumpy pro-legs only
GO TO PAGE 22
GO TO PAGE 25A
True fly larvae
DIPTERA
(page 112)


(from page 21)
attached to a solid surface
free to move, like a small jellyfish
free to move, not a jellyfish
Jellyfish
CNIDARIA
(page 34)
with tentacles
without tentacles, encrusts stones and wood
Freshwater sponges
PORIFERA
(page 32)
slender, without a suction cup
stout, with a distinctive suction cup at one end
Hydra
CNIDARIA (HYDROZOA)
(page 34)
crayfish symbionts
TEMNOCEPHALANS
(page 40)
with a hard shell
without a hard shell
GO TO PAGE 23A
GO TO PAGE 23B


A
(from page 22)
B
(from page 22)
Shell with two 'halves'
single shell, often coiled
Snails
GASTROPODA
(page 52)
shell contains a soft legless body
shell contains lots of legs
Mussels and clams
BIVALVIA
(page 46)
Seed shrimp and clam shrimp
OSTRACODS/CONCHOSTRACA
(page 66 and 67)
segmented
not segmented
GO TO
PAGE 24A
without suction cups
with suction cups on either end of the body
and without a hardened head capsule
and with a head capsule
GO TO
PAGE 24B
Leeches
HIRUDINEA
(page 41)
Black fly larva
DIPTERA
(page 129)


A
(from page 23)
B
(from page 23)
flattened, short and slimy
not flattened, long and thin
with tentacles (usually found on freshwater crayfish)
without tentacles
Crayfish symbionts
TEMNOCEPHALANS
(page 40)
Flatworms
TURBELLARIANS
(page 38)
shorter than 1.5 cm tapering
longer than 1.5 cm
Horsehair/gordian worms
NEMATOMORPHA
(page 37)
with a snout, fleshy
without a snout, wiry
Proboscis worms
NEMERTEA
(page 37)
Round worms
NEMATODA
(page 36)
with hard mouthparts (these can be inside the head and difficult to see)
without hard mouthparts
True flies
DIPTERA
(page 112)
GO TO PAGE 25B


A
(from page 21)
B
(from page 24)
with paired fleshy projections and palps (rare and small)
without paired projections, but sometimes with last half covered in fine gills
POLYCHAETA (not covered in this book)
Segmented worms OLIGOCHAETA (page 44)
with more than 10 legs (5 pairs)
with 10 legs
with 8 legs
with 6 legs (some might be covered by a portable case)
Crayfish, shrimp, crabs and prawns DECAPODA (page 77)
Spiders and mites ARACHNIDA (page 59)
long animal, all legs similar
short animal, legs varied
Millipedes MYRIAPODA (not covered in this book)
Mountain shrimp SYNCARIDA (page 73)
Assorted Crustaceans
Often smaller than a pinhead, lives on water surface
GO TO PAGE 31A
usually longer than 3mm, unlike collembola
Springtails COLLEMBOLA (page 84)
GO TO PAGE 26

(from page 25A)

with piercing/sucking mouthparts fused into a single spike (usually obvious)

True bugs
HEMIPTERA
(page 144)

with paired biting/chewing mouthparts (can be less obvious)

with a case

long legs, case never with coarse vegetation attached lengthways

Cased caddis flies
TRICHOPTERA
(page 187)

short, stumpy legs, case with coarse vegetation attached lengthways

Aquatic caterpillars
LEPIDOPTERA
(page 86)

without a case

with wing buds, well developed compound eyes, and legs

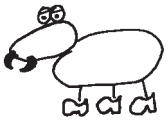
GO TO PAGE 28

without wing buds, less well developed eyes and legs

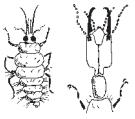
GO TO PAGE 27

(from page 26)

mouthparts short and curved



mouthparts straight and longer than head



Lacewing larvae
NEUROPTERA
(page 90)

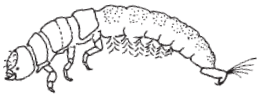
abdomen with 10 or 0 pairs of fleshy projections

abdomen with 7 or 8 pairs of fleshy projections

Dobson/Alder Flies
MEGALOPTERA
(page 89)

last abdominal segment without large hooked pro-legs

last abdominal segment with large hooked prolegs

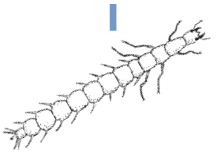


Free living caddis flies
TRICHOPTERA
(page 187)

body long, thin and cylindrical, first segment with an orange/brown rectangle

Scorpion fly larvae
MECOPTERA
(page 88)

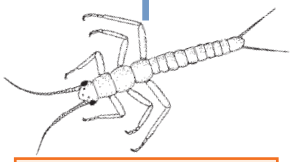
body highly variable (can be flat, rounded, dark or pale) but never like Mecoptera



Beetle larvae
COLEOPTERA
(page 92)

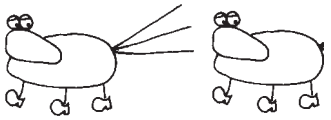
(from page 26)

with 2 tails

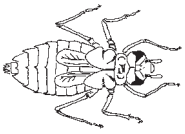


Stoneflies
PLECOPTERA
(page 180)

with 3 tails or no tail

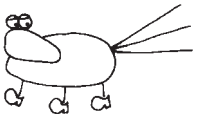


with 0 tails, jaw large and folded away under head



Dragonflies
ODONATA
(page 161)

with 3 tails



tails flattened, or broad, jaw large and folded away under head

Damselflies
ODONATA
(page 161)

tails thin, round in cross section

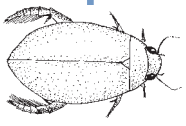
Mayflies
EPHEMEROPTERA
(page 131)

(from page 21)

forewings hard, covering hindwings at rest

forewings = hindwings, or without hindwings

forewings hard and meeting in the centre of the animal's back, mouthparts for chewing, or biting



Adult beetles
COLEOPTERA
(page 92)

forewings leathery, folded asymmetrically, mouthparts form a tube for sucking

True bugs
HEMIPTERA
(page 144)

with forewings only

True flies
DIPTERA
(page 112)

two fully formed pairs of wings

without tails

GO TO PAGE 30A

with tails

GO TO PAGE 30B

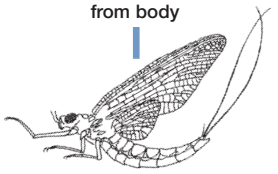
A
(from page 29)

B
(from page 29)

with 2 tails, wings folded along back

Stoneflies
PLECOPTERA
(page 180)

with 3 tails, wings held away from body



Mayflies
EPHEMEROPTERA
(page 131)

wings with scales, mouthparts long and coiled

Moths
LEPIDOPTERA
(page 86)

wings without scales, mouthparts not coiled

wings (and body) covered in hairs, antennae as long, or longer than body

Caddisflies
TRICHOPTERA
(page 187)

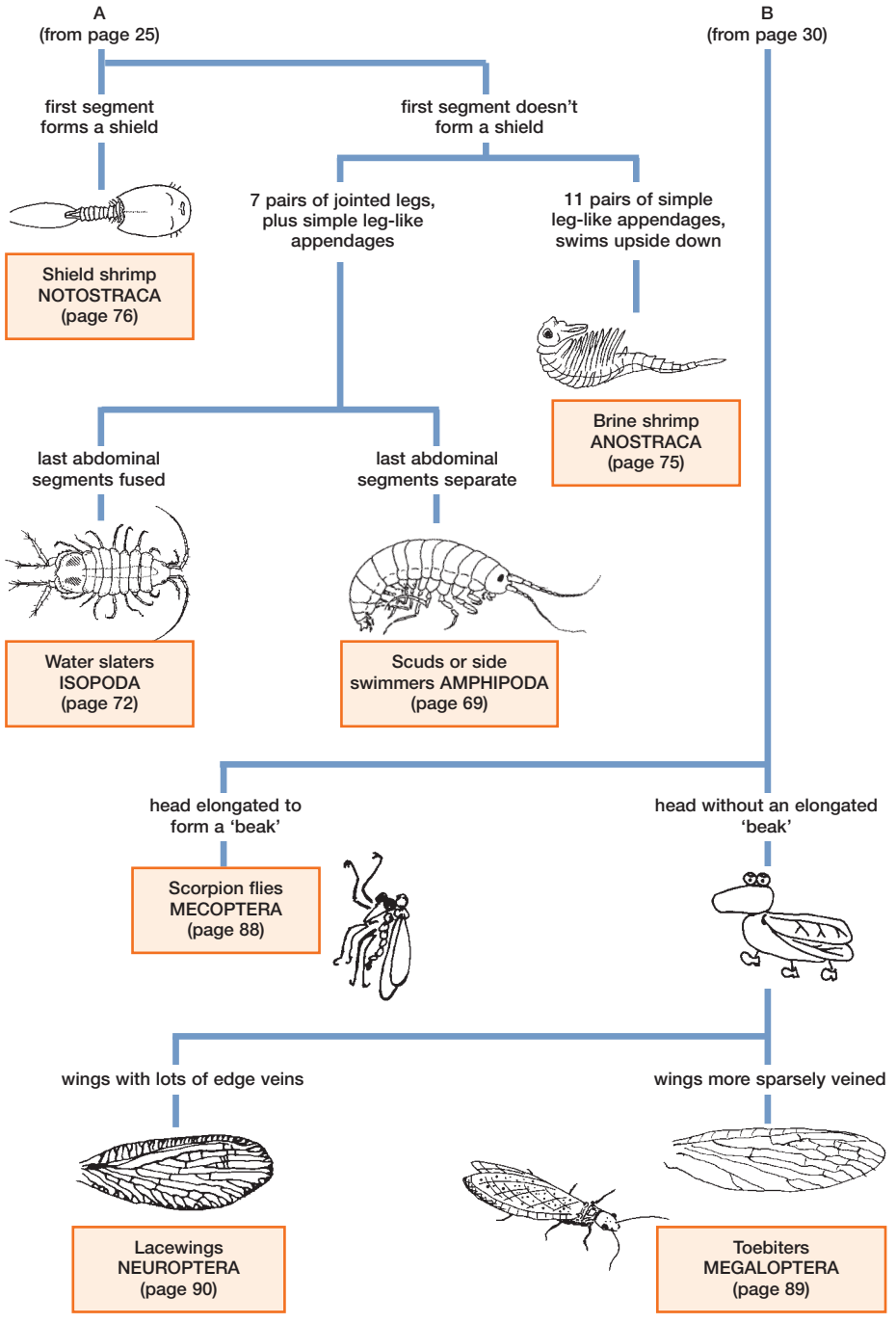
wings with few hairs

antennae small, eyes large, wings held as shown

Dragonflies and damselflies ODONATA (page 161)

wings fold flat against body

GO TO PAGE 31B


A
(from page 25)
B
(from page 30)
first segment forms a shield
first segment doesn't form a shield
Shield shrimp NOTOSTRACA (page 76)
7 pairs of jointed legs, plus simple leg-like appendages
11 pairs of simple leg-like appendages, swims upside down
Brine shrimp ANOSTRACA (page 75)
last abdominal segments fused
last abdominal segments separate
Water slaters ISOPODA (page 72)
Scuds or side swimmers AMPHIPODA (page 69)
head elongated to form a 'beak'
head without an elongated 'beak'
Scorpion flies MECOPTERA (page 88)
wings with lots of edge veins
wings more sparsely veined
Lacewings NEUROPTERA (page 90)
Toebiters MEGALOPTERA (page 89)

Freshwater sponges

(Phylum: Porifera, Family: Spongillidae)

Freshwater sponges are much smaller and less spectacular than their saltwater relatives. They are often confused with aquatic plants, algae or fungal growth because of their simple construction. In fact, until the eighteenth century, sponges were not recognised as animals.

Distinguishing characteristics

Sponges are primitive organisms and do not have any digestive, or reproductive organs. They are a rather peculiar colony of specialised cells that perform different functions but share a common skeleton. The skeleton is a mesh of microscopic needles, fibres and rods. The sponges sold in chemist shops are actually just skeletons.

Sponges are irregularly shaped, dull-coloured and can often be covered by or mixed with algae. Their body consists of a cavity surrounded by convoluted walls of softer tissue, held together by the skeleton and covered with cells that move water with small whip-like structures (flagellae).

Porifera translates as 'pore bearer' and the body wall has thousands of pores through which the water is sucked in and blown out while the animal feeds.

Classification and distribution

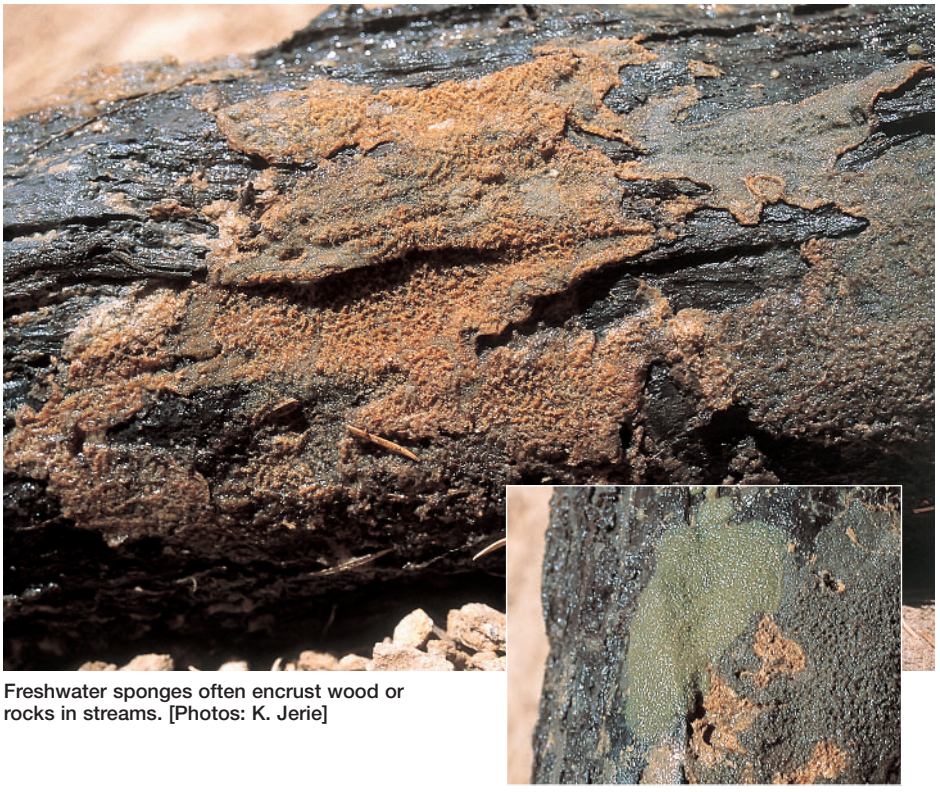
Nine genera and 24 species of freshwater sponges have been recorded in Australia. Most of them occur in New South Wales and Queensland. Only one species has been recorded in Tasmania and Victoria. Two species occur in South Australia and Western Australia. All of the freshwater sponges in south-eastern Australia belong to the family Spongillidae.

Freshwater sponges, 5–6 cm diameter. The green colour is due to algae living symbiotically within the sponge.

Habitat and ecology

Freshwater sponges are found on the undersides and edges of rocks and submerged wood, usually as thin crusts or mats. Freshwater sponges prefer slow moving, shallow waters, where there is a solid surface for them to grow on. Sponges can also occur in saline pools and in lakes with slightly saline waters.

Sponges feed by filtering organic particles from the water column. They draw water into the body cavity where various cells strain micro-organisms and organic debris from it. Food particles are then transferred to other cells throughout the body. A large



Freshwater sponges often encrust wood or rocks in streams. [Photos: K. Jerie]

quantity of food is absorbed by a sponge, and the larger marine species can filter several litres of water a day.

Natural history

Sponges can reproduce both sexually and asexually. When they reproduce sexually, they are hermaphroditic (one animal can produce both male and female reproductive cells). Once fertilised, the egg develops into a free-swimming larva propelled by specialised microscopic hairs (cilia) until it finds a suitable spot to attach and grow into a new sponge.

Asexual reproduction can occur in several ways. Sponges can produce small round lumps known as gemmules. Gemmules are surrounded by a protective membrane and spicules, this allows them to survive unfavourable conditions when the main body of the sponge is destroyed.

When conditions improve, the gemmules hatch and grow to form sponges that are genetically identical to the parent. Sponges can also voluntarily (or accidentally) split and form more separate animals. They have an amazing ability to regenerate. Even when ground up and squeezed through a cloth the small fragments re-build themselves into a new sponge.

Freshwater jellyfish and hydra

(Phylum: Cnidaria, Class: Hydrozoa)

Most cnidarians live in the sea. The phylum includes some of the best known marine invertebrates, the sea anemones and the colonies of coral polyps that created our spectacular coral reefs. Jellyfish like the dreaded 'blue bottle' also belong to the Cnidaria.

Distinguishing characteristics

The freshwater cnidarian body plan is a simple sack with a mouth opening used either as an entry for food or an exit for waste. Tentacles encircle the mouth and are used to catch food from the surrounding water. Most are smaller than 30 mm.

The most common freshwater cnidarian is *Hydra*, a solitary, sessile polyp. Sometimes polyps form a colony in which all polyps are connected to each other by thin stems. These colonies are often confused with plants because of their branching appearance. Some freshwater cnidarians occur as a medusa or jellyfish. These are virtually the same as a polyp, but flattened vertically and tipped upside down. The medusa has its mouth opening underneath its body, surrounded by hanging tentacles.

Classification and distribution

All of the freshwater Cnidaria belong to the Class Hydrozoa. Four genera: *Hydra*, *Cordylophora*, *Craspedacusta* and *Australomedusa* are found in south-eastern Australia.

Habitat

Hydra, the most common polyp, can be found in ponds, small lakes and mountain streams. They attach themselves to stones and submerged wood and can congregate in large groups. Colonial polyps (*Cordylophora*) also attach to wood and rocks in flowing waters, ponds and lakes.

A hydra, around 1 cm long, showing a tiny individual budding from its parent.

This group has been found in the salt waters of Lake Corangamite and even in the ornamental lake at the Botanical Gardens, in Melbourne. The free-living jellyfish (*Craspedacusta)* is known from lakes and reservoirs throughout south and south-eastern Australia and was one of the first animals to appear in Canberra's Lake Burley Griffin. Curiously this freshwater medusa, the size of a 50-cent coin, has been found in bird baths.

Ecology

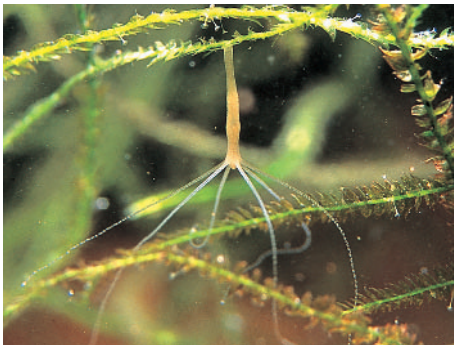
All cnidarians are predators. They use tentacles, armed with stinging nematocysts, to catch minute animals such as cladocerans and copepods.

While most freshwater cnidarians are sessile, *Craspedacusta* and *Australomedusa* freely float in the water column. *Hydra* polyps move around by slowly sliding the base of their body or by moving from their base to their tentacles and back to the base again, like acrobats doing somersaults.

Natural history

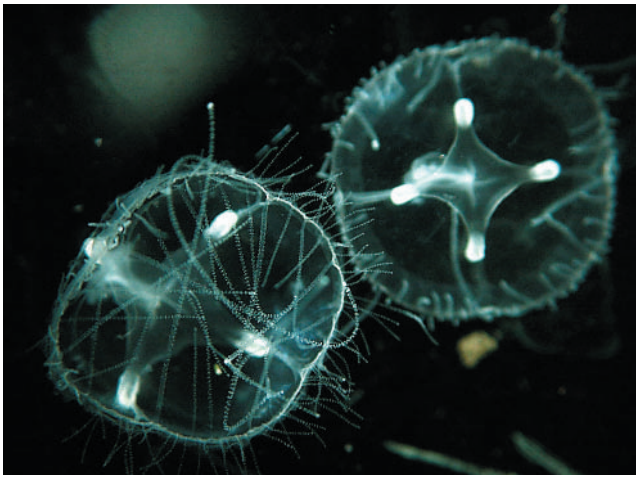
The name Cnidaria comes from the Greek word *knide*, which means stinging nettle. Cnidarian tentacles carry special cells called nematocysts, and these are responsible for stinging and killing prey. Nematocysts have a long, coiled, sometimes venomous or sticky thread attached to a harpoon-like head and these are fired from the cells into prey. In blue bottles, thousand of nematocysts are powerful enough to kill a fish and give humans a severe sting. However, freshwater cnidarians are absolutely harmless as their prey are microscopic.

Cnidarians alternate between the polyp and medusa life forms with the medusa usually producing male and female reproductive cells and the polyps reproducing asexually.



Hydra can be quite inconspicuous amongst vegetation. The tentacles form a deadly net to catch unwary prey.

In *Hydra*, the medusa stage is absent and the polyp takes over and reproduces both sexually and asexually by budding. *Cordylophora,* the colonial form, is simply a communal variation on *Hydra* with a group of polyps joined together after incomplete budding. In comparison, the lifecycle of *Craspedacusta* and *Australomedusa* is dominated by relatively large and free floating medusae, alternating with a minute hydra-like polyp.



The freshwater jellyfish *Craspedacusta sowerbyi* measures less than 5 cm in diameter. [Photo: Gen-yu Sasaki]

Both the term Hydra and Medusa are from Greek mythology. The Hydra was a many headed water serpent that Heracles (or Hercules) had to slay as one of his twelve tasks. Medusa was a powerful monster who had snakes for hair. Her look could turn her victims to stone and she was eventually slain by another Greek hero, Perseus. Both animals look a little like the original mythical beasts, but on a much smaller scale.

Unsegmented worms: nematodes, nemerteans, horsehair worms, flatworms and crayfish symbionts

This group of animals is united by the simplicity of their shapes. They all have simple digestive systems, some have a single opening, like the flatworms (including the temnocephalans), while others like the gordian worms have none at all.

Round worms or nematodes (Phylum: Nematoda)

Distinguishing characteristics

Nematodes are small pale worms without segments. They are often translucent and can be curved to the extent that they form a rigid loop. When moving, they will often thrash around, coiling and uncoiling very quickly. They are very small, the largest specimens reaching 4 mm.

Classification and distribution

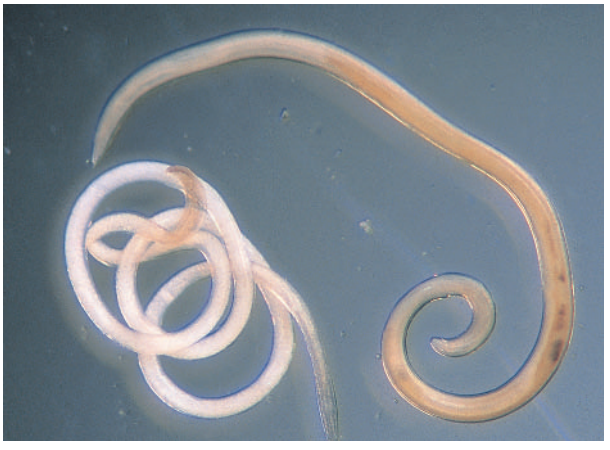
Nematodes are incredibly diverse. The 49 genera known from freshwaters in south-eastern Australia are easily outnumbered by the estimates of terrestrial and parasitic nematodes in the same region. They are also very numerous, a single rotting apple can hold around 90,000 terrestrial individuals.

Habitat and ecology

Nematodes can survive anywhere there is sufficient moisture. Many species are parasitic on other freshwater animals and the nematodes found in freshwater are a combination of free-living forms and animals caught between hosts. Nematodes can be predatory, parasitic, or live on bacteria, fungi and plants.

Natural history

Nematodes were named from the Greek word *nema* meaning thread. They are one of the most widely dispersed animals on the planet and turn up in polar conditions, at the bottom of marine trenches and even in hot springs. It has been said that if every other animal and plant in the world was removed in an instant, we would still be able to see their outlines (and the outlines of their internal organs) traced out in nematodes.



Nematodes are small, pale, unsegmented worms with sharp ends.

Nemerteans (Phylum: Nemertea)

Distinguishing characteristics

The nemerteans are small, pale, unsegmented worms with a distinct snout and a row of small eyespots. They are rarely longer than 2.5 mm.

Possible misidentifications

Small oligochaetes with indistinct segmentation may appear similar, but examination under a microscope should allow the two to be separated.

Classification and distribution

Little is known about the taxonomy of this group in Australia, but it is possible that the main species found was introduced with aquatic plants.

Habitat and ecology

Nemerteans occur in slow-flowing environments such as permanent ponds and backwaters. They hunt for microscopic prey amongst the foliage of aquatic plants.

These nemerteans are about 1.5 mm long including their long, barbed mouth-tube.

Natural history

Nemerteans have a long, barbed mouth-tube (or proboscis) with which they hunt their prey. The structure is hollow and attached directly to the stomach and this allows smaller prey to be swallowed whole, while larger prey are stabbed, poisoned and then swallowed whole. This armoury, together with silent ciliated movement (see turbellaria) makes the nemerteans formidable predators at a really small scale.

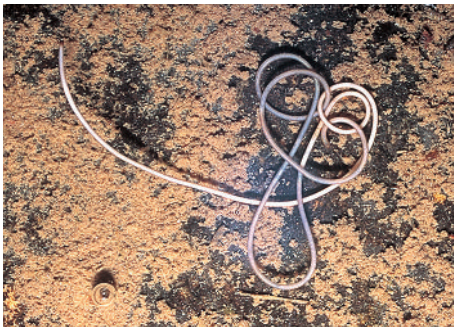
Horsehair or gordian worms: Gordioidea (Phylum: Nematomorpha)

Distinguishing characteristics

Gordian worms are usually found as thin, long adults in freshwaters. They can be darkly coloured and have a wiry body that moves purposefully. Their slow movement, length and dark colouring means that they are sometimes mistaken for wire or twine. Gordian worms are often longer than 50 mm, but seldom thicker than 3 mm.

Classification and distribution

There are six genera of Nematomorpha in south-eastern Australia, none is endemic.



Gordian worms are sometimes mistaken for wire or twine.

Habitat and ecology

Adult gordian worms are free living, in a variety of fast and slow-flowing aquatic habitats. The adult form does not feed, but larvae and maturing gordian worms are parasites that live inside insect hosts, absorbing their food (the host's blood) through their skin.

Natural history

Adults may live for several months, but die soon after mating and laying clusters of eggs in the water. The newly hatched larvae are inadvertently consumed by aquatic insects. In some tropical species, these primary hosts must emerge as adults and be eaten by a praying mantis before the worms can properly mature. In temperate Australia, it is more likely that worms either remain in a single host, or have their hosts eaten by more common predators such as dragonflies or beetles. Given the relative sizes of host and mature parasite, the host eventually dies and the tightly coiled adult worm then leaves the body and takes to the water to find a mate.

Flatworms: turbellarians (Phylum: Platyhelminthes)

Distinguishing characteristics

Flatworms are flat, slow moving and thin. They come in a variety of colours, from the dullest greys to jade green. The stream-dwelling species are normally long and dully coloured, but wetland species can be highly variable in both colour and shape. Most freshwater species are under 20 mm long.

Possible misidentifications

Because of their movement, they may appear similar to nemerteans, but nemerteans are slender and pale.

Classification and distribution

Seven genera of turbellarians occur in south-eastern Australia. In rivers and lakes the commonest of these are *Cura*, *Dugesia* and *Spathula*. The first two are common in lowland systems, while *Spathula* is found at higher altitudes.

Habitat and ecology

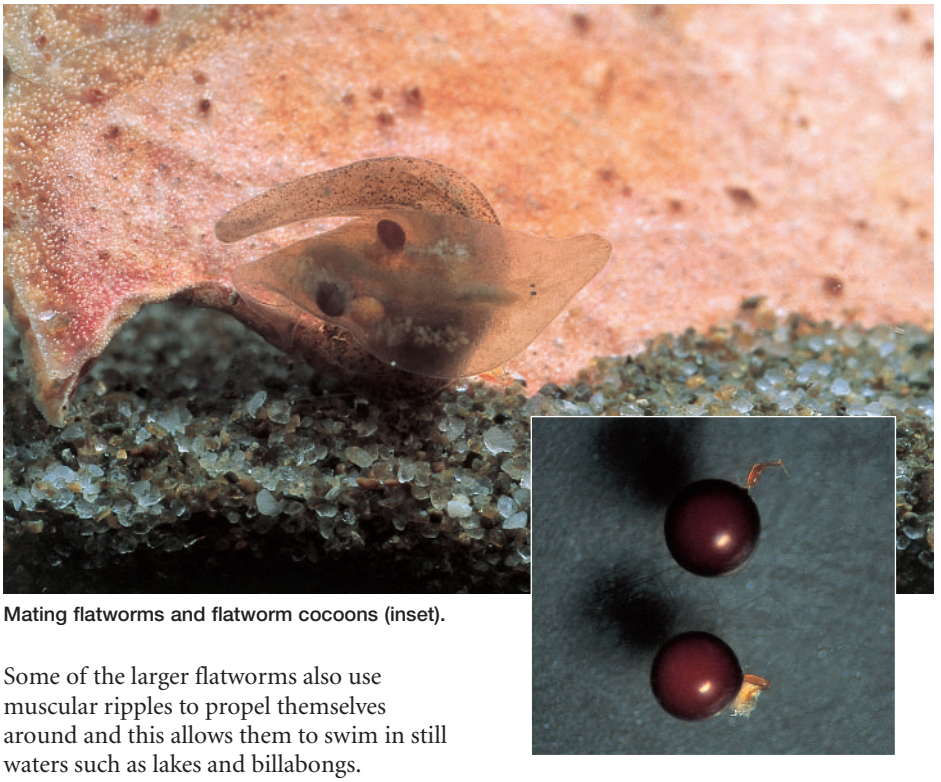
Flatworms are omnivorous animals feeding partly on prey and partly by scavenging. They occur on the undersides of rocks and wood, in a variety of flow conditions.

Natural history

Flatworms move using short microscopic bristles (cilia) on a path of mucus and this gives them their unearthly, gliding motion.

Cura sp. can be recognised by its rounded head.

Dugesia sp. can be recognised by its arrow-shaped head and large eyes.



Mating flatworms and flatworm cocoons (inset).

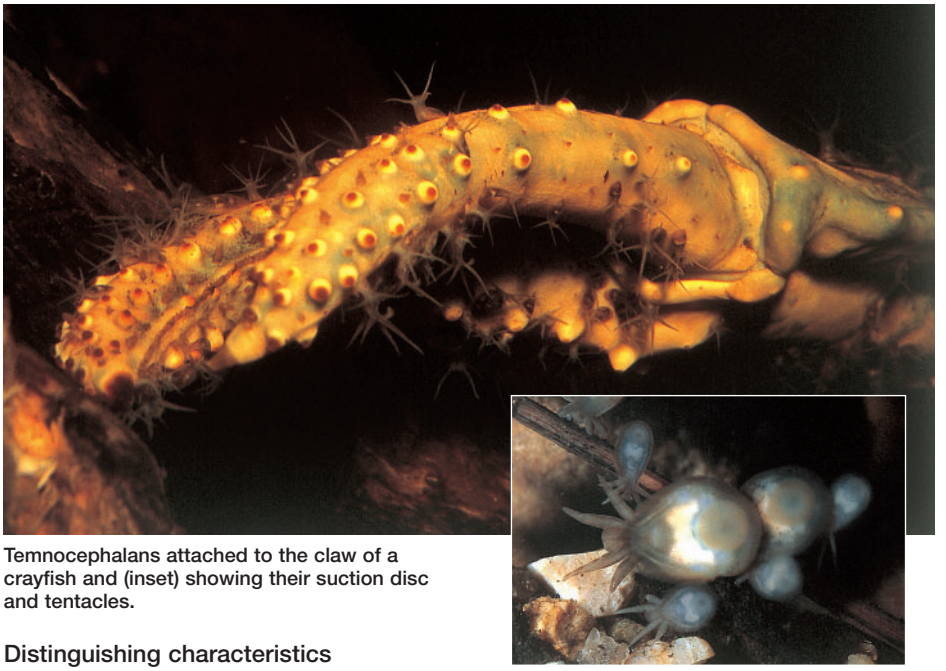
Some of the larger flatworms also use muscular ripples to propel themselves around and this allows them to swim in still waters such as lakes and billabongs.

Flatworms are also well known for their ability to regenerate from damage. If an individual is cut in half, it is possible for both parts to form separate individuals.

Flatworms can reproduce sexually and asexually. They lay their eggs in tough, leathery cocoons that are resistant to drying and predation.

Some wetland flatworms (*Mesostoma* sp.) display a range of body colours from semitransparent to bright green.

Crayfish symbionts: temnocephalans (Phylum: Platyhelminthes)



Temnocephalans attached to the claw of a crayfish and (inset) showing their suction disc and tentacles.

Distinguishing characteristics

The temnocephalans have flat, squat bodies with two to six tentacles at one end and a suction disc at the other. They are grey, brown or white and are almost always found on freshwater crayfish. They rarely grow larger than 12 mm.

Classification and distribution

Several genera and numerous species of temnocephalans occur in south-eastern Australia. Most genera are endemic, but the six-tentacled *Temnohaswellia* is also found in New Zealand. The genus *Temnocephala*, once thought to occur in Australia, Asia and South America, is now known to be restricted to central and south America.

Habitat and ecology

Temnocephalans occur as external symbionts, mainly on freshwater crayfish but also on the larger species of freshwater prawn. Some are predators, feeding on small invertebrates. Others may browse on microflora (bacteria and algae). They do not harm their hosts and can survive without them for prolonged periods. They capture food using their tentacles.

Natural history

Temnocephaland are usually very mobile animals, looping leech-like over the surface of crayfish. They are, like all flatworms, hermaphrodites. After mating they lay small leathery cocoons, sometimes on a stalk, which they stick onto the external skelton of their host, and from which small immature worms hatch.

Freshwater leeches

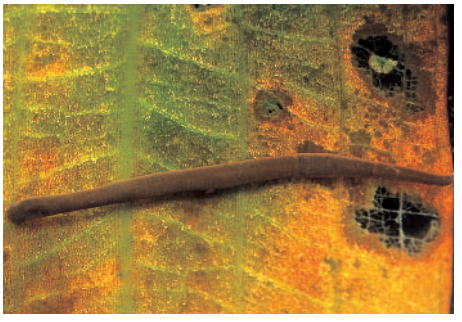
(Phylum: Annelida, Class: Hirudinea)

To many people leeches are not very charismatic animals due to their annoying habit of sucking blood from people's legs. However, freshwater leeches are fascinating to study as they possess powerful sensory organs and can display complex parental behaviour.

Since medieval times leeches have been used for medicinal purposes. The most famous medicinal leech is *Hirudo medicinalis*, a species of bloodsucking aquatic leech from Europe. In Australia and New Zealand, the native 'tiger leech' (*Richardsonianus*) is used in microsurgery, plastic surgery and for treatment of thrombosis. Apart from being excellent blood pumps, leeches release substances such as anticoagulants that prevent blood clotting and assist in surgery. A leech's bite is practically harmless though some people can develop an allergic reaction or a secondary bacterial infection.

Distinguishing characteristics

Leeches have a body made up of 32 segments and this number is constant for all species. They have a smaller anterior sucker and a larger cup-like posterior one. Some leeches like glossiphoniids crawl by moving the anterior sucker forward, attaching it, and drawing up the posterior sucker while hirudinids and erpobdellids can swim by rapidly undulating their body. Adult leeches range from 7 mm to about 20 cm in length. Their length is difficult to measure since leeches constantly contract and stretch their bodies. Often the body form is elongated and flat but some are cylindrical. This can vary depending on the stage of the movement and whether the leech is starved or has just had a meal. During swimming, the bodies of the Hirudinidae and Erpobdellidae become flattened to form a kind of a keel that makes them resemble miniature eels. Leeches have one or more pairs of eyes. Their bodies are usually black and brown and can be patterned with stripes and spots.



An erpobdellid leech can easily stretch to three times its normal size.

It is possible to distinguish three common families in south-eastern Australia: glossiphoniids have a flattened or pear-shaped body, hirudinids are distinctly striped and erpobdellids are thin and elongated.

Possible misidentifications

Leeches are difficult to confuse with other worms, though smaller specimens might resemble turbellarian flatworms. Leeches can easily be distinguished by their segmented bodies and the presence of suckers. Leeches can also be confused with oligochaet worms (see pages 44–45).

Classification and distribution

Five families of freshwater leeches are found in Australia: Glossiphoniidae, Ozobranchidae, Hirudinidae (formerly Richardsonianidae), Ornithobdellidae and Erpobdellidae. Of these, Glossiphoniidae is most common in south-eastern Australia followed by the Hirudinidae such as the 'tiger leech' (*Richardsonianus*) and Erpobdellidae. Ornithobdellids are restricted to tropical Queensland and examples of the Ozobranchidae are quite rare.

Habitat and ecology

Leeches are predators. Most of them use ambush tactics while some genera, such as *Motobdella* (Family: Erpobdellidae), actively seek their prey. Many leeches use their proboscis to suck the insides from worms, molluscs and midge larvae, just like a vacuum cleaner. Others use their sharp jaws to feed on the blood of frogs, turtles, water birds, cattle and some inquisitive biologists. Blood-sucking leeches are able to detect minor water disturbances so an easy way to catch them is to dangle something (even your hand if you are brave) in the water. Leeches occur in a wide range of freshwater habitats.

A glossiphoniid leech showing the typically arched body, mid-step.

A glossiphoniid leech showing eye spots.

A glossiphoniid leech with a brood of young on its ventral surface.

Hirudinid leeches (*Richardsonianus* sp.) are good swimmers and have distinctive stripes.

Glossiphoniids prefer running waters while the hirudinids and erpobdellids are more likely to occur in stagnant and slow moving waters. Some groups can tolerate low oxygen concentrations and high levels of water pollution. To cope with low oxygen concentrations leeches often ventilate their body surface by performing swimming movements while being attached to some hard surface. Most leeches are active and hunt at night.

Natural history

Leeches are hermaphroditic. They carry male and female sexual organs and can easily swap between reproductive roles. Leeches playing the role of a male can sometimes display courtship behaviour. The young leeches hatch from eggs as miniature copies of adults. Parental behaviour of leeches ranges from simply dropping their eggs to extreme and tender care and many glossiphoniid leeches carry their young underneath their bodies for some time before releasing them into the outside world. F. Goveditch, an expert in leeches, reported that some leeches (e.g. *Glossiphonia*) even transfer nutrients across the body wall to their developing young. He also observed that the reproductive strategy of some male Glossiphoniid leeches is to try to impregnate as many female leeches as possible before switching gender and trying to get pregnant themselves.

Segmented worms

(Phylum: Annelida, Class: Oligochaeta)

Freshwater oligochaet worms are plain-looking animals. They can look like ordinary earthworms but more often they are much thinner and shorter. They are all segmented, and if you use a microscope you can observe short bristles and hairs on each segment.

Distinguishing characteristics

Freshwater oligochaet worms can be red, tan, brown, cream or black in colour and some of them sport noticeable external features. For example, some species of *Nais* have pigmented eye spots that make them look like sock puppets, while *Branchiura sowerbyi* has dorsal and lateral gills. Species of *Dero* have elongate growths at the posterior tip of their bodies. These protuberances act as gills increasing body surface area and helping the worm to trap more oxygen. All of the aquatic worms characteristically move by stretching and pulling their bodies. The blackworm, *Lumbriculus variegatus*, is often sold as fish food in aquarium shops and is one of the more common and widespread species.

Possible misidentifications

Small oligochaetes can be confused with leeches. The main feature that helps to separate these groups is the presence of a sucker on leeches and the leech's ability to lift one end of its body off the ground. The texture of leeches (when they are dead) is much harder. Oligochaetes have a variable number of segments while leeches always have 32 segments.

Classification and distribution

The class Oligochaeta includes about 3500 species of earthworms and freshwater worms globally, with at least 90 species of freshwater worms recorded in Australia. The class Oligochaeta is usually divided into two superorders: the larger worms or Megadrili (from the Greek: *mega* = large, *drilos* = penis or worm), which is closely related to and resemble the common earthworms, and the much smaller worms of the Microdrili (Greek for 'small worms').

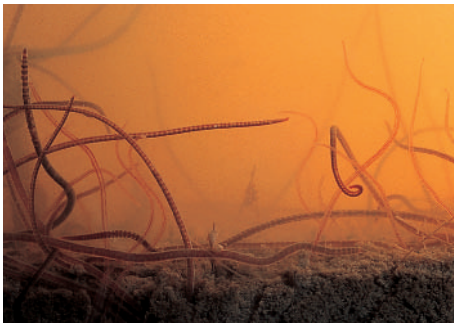
The majority of worms found in freshwater belong to the Microdrili, many of them are only several millimetres long. Some species such as *Lumbriculus variegatus* and *Aulorilus sp.* are found worldwide while other genera (e.g. *Antipodrilus*) are restricted to the southern hemisphere. The common families in Australia are Lumbriculidae, Enchytraeidae, Naididae, Tubificidae, Phreodrilidae and Haplotaxidae.

Habitat and ecology

Most oligochaetes live in soft sediment rich in organic matter, and the common name, 'sludge worms', for the tubificids clearly describes their habitat. Bacteria and algae that abound in sludge and fine sediments are the main source of food for worms, but some species of *Chaetogaster* (from the family Naididae) are carnivorous. Their large mouth opening and relatively short body make them look like microscopic living macaroni. Another naidid worm, *Chaetogaster limnaei*, is a symbiont of freshwater snails and clams. It lives in their mantle cavity.

The black worm, *Lumbriculus variegatus*, is very common and is often used as food for aquarium fish.

Branchiura sowerbyi, a tubificid worm, has conspicuous finger-like gills along the posterior half of its abdomen.



Tubificid worms burrow head first into the mud.

Pristina sp. has a characteristic anterior proboscis.

Environmental significance

Oligochaetes are probably the only freshwater invertebrates that can occur in totally degraded habitats such as sewage outlets and degraded urban streams. They seem to survive in streams with nutrient and pollution levels many times greater than the accepted level. Some worms can live in waters with an oxygen concentration close to zero.

Oligochaetes are so tolerant they often serve as an indicator of poor health in aquatic habitats. While worms are one of the most tolerant macroinvertebrates, they are not restricted to polluted waters and also occur in pristine habitats.

Natural history

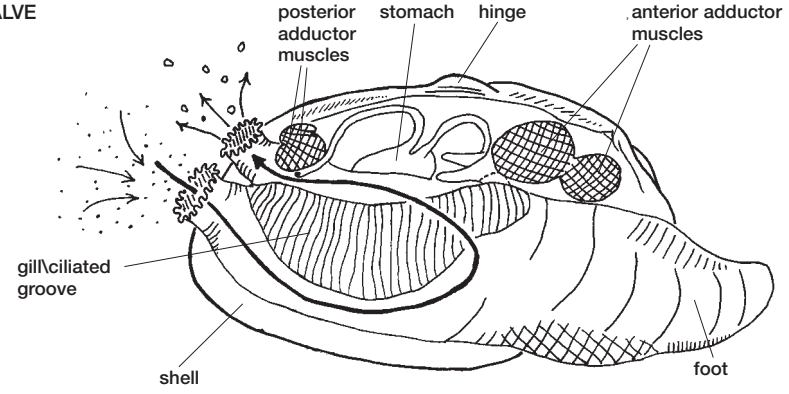
Most freshwater worms are hermaphrodites, possessing both male and female reproductive organs. They reproduce sexually or by fission. A specialised budding segment at the tail end of the worm can start growing to give rise to a new worm. The newly formed worm either breaks off from its parent or continues budding forming another worm whilst still attached to the parent. These newly formed worms are called zooids. When reproducing sexually, oligochaetes produce a cocoon in which they deposit fertilised eggs. When the young worms emerge from the cocoon they look like miniature adult worms.

Freshwater snails, mussels and clams

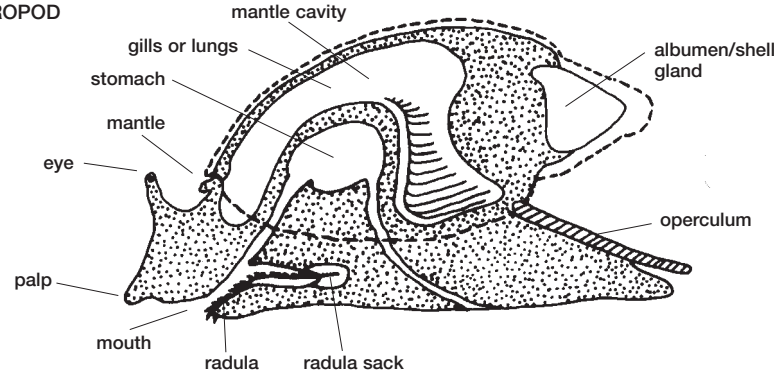
(Phylum: Mollusca, Classes: Bivalvia and Gastropoda)

Chitons, clams, cuttlefish, mussels, octopus, squid, snails, and slugs are all molluscs, but only two classes, the bivalves and the gastropods, have successfully left the sea and invaded the land and its freshwaters.

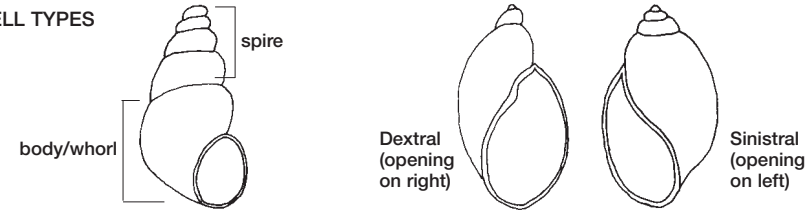
BIVALVE



GASTROPOD



SHELL TYPES



Distinguishing characteristics

Mussels and clams (the bivalves) are usually closed when we find them and the fleshy body within the paired valves is rarely seen. The shells vary a lot in thickness and size, some of the hyriids are longer than 10 cm when fully grown, while the sphaeriids never exceed 10 mm. If they are left alone long enough, most bivalves reveal a strong, fleshy foot, with which they can burrow into finer sediments. Bivalves are rather descriptively named: *bi* is the Greek for two and *valva* were originally the individual 'leaves' of a folding door.

The freshwater snails (the gastropods) of temperate Australia are all soft-bodied animals that carry a hard, often coiled shell upon their backs, into which they can withdraw when threatened. Their heads carry a pair of eye stalks and a pair of tentacles, though one or both of these are less obvious in some freshwater species. Sometimes the retreating animals will have a door or 'operculum', which blocks the entrance to the shell once the animal is inside. The name gastropod is from the Greek, meaning stomach (gastro-) footed (-poda), referring to the way the animal's stomach is so close to its foot.

The origin of freshwater molluscs

Both bivalves and gastropods are primarily marine organisms—they evolved in the sea. Freshwater bivalves are likely to be descended from a string of successive species that worked their way up through the estuaries into the freshwater where we find them today. Each step left a new suite of species, tolerant of slightly lower salinities.

Some gastropods may have found their way into freshwaters the same way, but as they moved upstream, they followed two distinct evolutionary paths. One group made the transition without greatly altering its shape: these were the operculates, named after the operculum or door that closes their shells. The other group simplified its gills and developed an empty chamber or lung to breathe with. This second group gave rise to the ancestors of the land snails and also the ancestors of the pulmonate, or 'lung bearing', freshwater gastropods. This group includes the Lymnaeidae, Planorbidae, Physidae, Ancylidae and possibly the Glacidorbidae. Interestingly, many of these snails have evolved further and are once again equipped with gills. However, some of the Lymnaeidae and Physidae retain the 'lung' and this has allowed them to carry their own air supply in particularly oxygen-poor environments. Sometimes these snails can be observed just under the water surface breaching the surface tension and refilling their air supply.

The freshwater mussel, *Velesunio* sp. showing siphons (right), and a muscular foot (left).

The freshwater snail *Glyptophysa* sp. showing palps, foot and shell. Its eye is at the base of its tentacle, rather than at the tip.

Classification

There are 7 genera of bivalves from 3 families and about 34 genera of gastropods from 10 families that occur in the non-marine waters of temperate Australia. This makes the freshwater mollusc fauna quite diverse and if present trends in gastropod taxonomy continue, there will doubtless be many more species described.

Environmental significance

The freshwater molluscs are such a diverse group that it is impossible to make a general comment on their sensitivity to pollutants. However, introduced species, such as *Potamopyrgus antipodarum* and *Physa acuta*, do tend to thrive under degraded conditions and can be seen as indicators of poor water quality and particularly nutrient enrichment.

Key to the families of Mollusca (after Smith 1996)

1	animals snail, or limpet-like (class Gastropoda) with a single whole shell **4**
1	animals clam, or mussel-like (class Bivalvia) with two halves of shell **2**
2(1)	shell halves large, thick, not symmetrical, often with dark coloured outer layer that flakes off near the hinge ..... **Hyriidae** (p. 50)
2	shell halves small, thin relatively symmetrical and round **3**
3(2)	shell very small (<6 mm), thin and almost transparent ..... **Sphaeriidae (or possibly immature Hyriidae/Corbiculidae)**(p. 51)
3	shell larger than 6 mm, opaque, and sometimes with concentric ridges ..... **Corbiculidae** (p. 49)
4(1)	animal with operculum 8
4	animal without operculum 5
5(4)	shell coiled 7
5	shell simple, limpet-like **8**
6(5)	shell can be larger than 5 mm, adorned with remnant spiral, and ribs ..... **Planorbidae (genus *Ancylastrum*)** (p. 56)
6	shell smaller than 5 mm, simple ..... **Ancylidae** (p. 51)
7(5)	shell sinistral (opening on left), tentacles slender ..... **Planorbidae/Physidae** (p. 56)
7	shell dextral (opening on right), tentacles squat and triangular ..... **Lymnaeidae** (p. 54)
8(4)	shell small, coiled but flat (without spire) ..... **Glacidorbidae** (p. 53)
8	shell coiled with spire **9**
9(8)	shell sculptured with spiral ridges, grooves and longitudinal ribs, can be as large as 25 mm ..... **Thiaridae** (p. 58)
9	shell without sculpturing, or with less complicated sculpturing **10**
10(9)	animal found in salt, or coastal lakes, high spired ..... **Pomatiopsidae** (p. 57)
10	animal found in freshwater, or at the estuarine end of rivers **11**
11(10)	operculum with spiral pattern, typically smaller than 10 mm ..... **Hydrobiidae** (p. 53)
11	operculum patterned with concentric rings, can be larger than 10 mm ..... **Bithyniidae/Viviparidae** (p. 52)

Radulas and the ciliated groove

Freshwater gastropods have highly muscular mouthparts that include a file-like structure called a radula. The radula scrapes food with rows of tiny sharp teeth, each row removing another chunk of food.

A backward and forward motion allows the food to be rasped and then ratcheted towards the back of the mouth cavity. The radula wears at one end but is replaced at its origin, the radula sac.

Bivalves have a similarly novel method of feeding. They feed from the water column, pumping water in through a siphon. The water is then sieved and food and rubbish are sorted as they travel towards the mouth along a structure known as the ciliated groove. Cilia are small hairs that can move and these push and sort the detritus. Water and rubbish that has been sorted are then exhaled by the bivalve through a second siphon, while food particles are wrapped in mucus and travel to the mouth and digestive system. The water pumped through the body also passes over the gills bringing a constant supply of fresh, oxygen-rich water.

The radula of a hydrobiid snail helps it scrape algae and bacteria from hard surfaces.

Little basket shells (Class: Bivalvia, Family: Corbiculidae)

Distinguishing characteristics

The corbiculids are medium-sized bivalves with opaque, cream–pink/purple coloured shells. The shells are slightly asymmetrical, sculptured with concentric ridges, and measure between 10 and 25 mm long.

Possible misidentifications

Small specimens can resemble the Sphaeriidae but these generally have comparatively transparent shells. There are larger genera than *Corbicula* in northern Australia, but anything larger than 25 mm in south-eastern Australia is likely to be an underdeveloped hyriid mussel such as *Velesunio* sp. or *Hyridella* sp.

Corbicula sp. showing its ridged shell. Little basket shells can be found in large numbers in sandy sections of some rivers.

Classification and distribution

One genus *Corbicula* (previously *Corbiculina*) is found in mainland Australia but not Tasmania.

Habitat and ecology

Corbiculids live buried in the sands of shallow fast moving streams. They feed by filtering food particles from the water.

Natural history

Corbiculids are sometimes found in large enough numbers to block irrigation equipment. The young develop briefly within the protective shell of the parent, before being released into flowing water in large numbers. They then aggregate in suitable sections of river, or irrigation equipment.

Freshwater mussels (Class: Bivalvia, Family: Hyriidae)

Distinguishing characteristics

Mussels from the family Hyriidae superficially resemble the well-known marine mussels. Their shells are thick and covered in a dark, flaky, outside layer, which can wear off near the hinge. Some are quite oblong-shaped, while others appear quite symmetrical and rounded. They vary in size, between 40 and 120 mm.

Possible misidentifications

Immature specimens can be confused with the Corbiculidae. The hyriids are usually more darkly pigmented.

Classification and distribution

Four genera and 11 species of Hyriidae occur in south-eastern Australia.

Velesunio sp. lives partially buried in fine sediments. Its shell can be found in the mud alongside irrigation canals in central Victoria.

Cucumerunio is from New South Wales. *Alathyria*, *Velesunio* and *Hyridella* all have representatives in patches throughout south-eastern Australia.

Habitat and ecology

The hyriids live in lowland river systems. They burrow in the finer sediments such as sand and mud, using a muscular foot to drag the shell below the surface. Freshwater mussels also commonly occur in irrigation canals and connected farm dams. When filter feeding, the hind edge of the shell remains exposed, allowing a pair of siphons to pump water from the passing flow into the shell, where the food and rubbish are sorted from it.

Natural history

The hyriids spend their early life as a small, simply formed parasite on the gills of native fish. The young attach themselves to the gill tissues of fish with hooks and remain there until they have developed. The young mussels drop free from their host with a fully developed siphon system and take to the softer sediments alongside the adult forms.

Fully grown freshwater mussels are renowned for being able to clear a bucket of muddy water overnight and are also able to tolerate prolonged dry spells, burying themselves in the mud and sealing their shells tight until water returns.

Pea shells (Class: Bivalvia, Family: Sphaeriidae)

Distinguishing characteristics

The sphaeriids are the smallest of the freshwater bivalves measuring a maximum of about 10 mm across. The shells are translucent and very thin.

Possible misidentifications

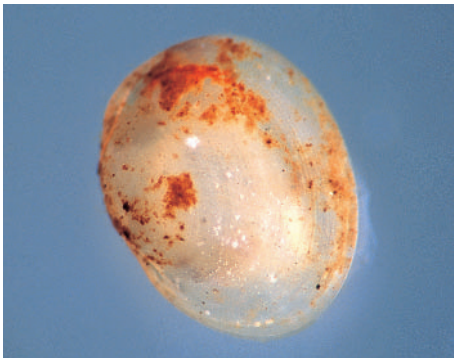
See Corbiculidae and Hyriidae.

Classification and distribution

Two genera, *Sphaerium*, usually 5 to 10 mm across, and *Pisidium*, a smaller genus, occur across south-eastern Australia.

Habitat and ecology

Pea shells occur in rivers, creeks or ponds, where there is sufficient fine sediment for them to burrow in. They are filter feeders.



The shells of the minute freshwater clam, *Pisidium* sp., are translucent.

Freshwater limpets (Class: Gastropoda, Family: Ancylidae)

Distinguishing characteristics

Ancylids are small gastropods (<4 mm) with simple shells that lack coiling. The shells also lack sculpturing or ribs, though they can sometimes sport a healthy growth of fine algae. The animal is rarely visible beneath its shell.

Possible misidentifications

The ancylids are very distinctive and can only really be confused with the planorbid gastropods from the genus *Ancylastrum*. These animals differ by having distinct ribs upon their shells and the remnants of a coiled shell. They are also only found in lakes on the central plateau of Tasmania.

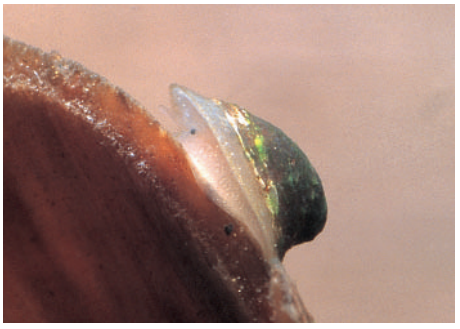
Classification and distribution

One genus with two species is recorded from south-eastern Australia. *Ferrissia tasmanica* has a darkly pigmented layer immediately beneath the shell (the mantle) and is slightly deeper in profile than *Ferrissia petterdi*.

Habitat and ecology

Freshwater limpets occur in streams, ponds and lakes, on a variety of surfaces. They can handle a variety of flow speeds and will occur on rocky substrates, woody debris and amongst macrophytes. They graze upon the periphyton available on all these surfaces.

The freshwater limpet *Ferrissia petterdi* with an oddly developed shell.



The shell of *Ferrissia tasmanica* can be covered in algae.

Natural history

Freshwater limpets in other countries have slightly different shells depending on the speed of the water they occur in—in fast flow they tend to have lower sleeker-shaped shells. If this is true for Australian species, we would expect *Ferrissia petterdi* to be a stream species rather than a pond or lake species. Ancylids in other parts of the world live for about a year and are hermaphroditic, but cannot fertilise themselves as sperm and ova are kept separately within their bodies.

Class: Gastropoda, Families: Bithyniidae and Viviparidae

Distinguishing characteristics

The snails from both these families have squat, dextrally coiled shells (opening to the right) and an operculum patterned with concentric rings. They are also both anonymously cream–brown coloured. The bithyniids are slightly smaller when fully grown, reaching a maximum of 12 mm, while the viviparids can be twice this size. The two families also differ in that the middle concentric ring on the operculum of the Viviparidae is slightly off-centre.

Possible misidentifications

Some of the Hydrobiidae may appear similar, but these have a spiral pattern on their operculum, rather than a set of concentric rings.

These examples of *Notopala* were found in a lowland river. [photo: K. Jerie]

Classification and distribution

One native genus (*Notopala*) with about five species represents the Viviparidae in south-eastern Australia. An introduced viviparid aquarium snail (*Bellamya heudei guangdungensis*) can also be found in the Sydney region. One genus of the Bithyniidae is found in south-eastern Australia: *Bithynia* (formerly *Gabbia*) with four species. These two families are currently being revised, so an increase in species numbers is likely.

Habitat and ecology

The Australian forms of both these families occur in inland systems, such as the Murray-Darling and the Lake Eyre Basins. Both are grazers of periphyton and occur in slow moving or still waters. Bithyniids are tolerant of mild salinities.

Natural history

The viviparids are named after the fact that the young mature inside eggs while still inside the parent and the parent then gives birth to live young. This is unusual among snails, which normally lay eggs externally and inevitably lose some to egg predators.

Live bearing increases the number of young that survive, as they are released into the outside world as mobile individuals. The viviparid snail *Notopala hanleyi* was thought to have become extinct in the lower Murray system sometime in the 1970s, until a large population was discovered blocking irrigation pipes in the area. The animal's local extinction is thought to be due to its dependence on food sources that have become drastically altered by flow regulation.

Class: Gastropoda, Family: Glacidorbidae

Distinguishing characteristics

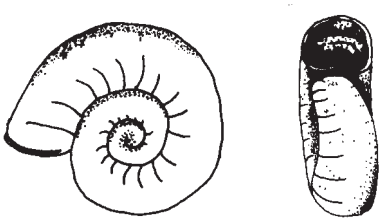
The glacidorbids are small, flat, coiled snails usually with yellow–brown shells. They have an operculum, though this may be difficult to see as the entire animal rarely exceeds 6 mm in length.

Possible misidentifications

Some of the planorbids are flattened in a similar way to the glacidorbids, but they are larger and do not have an operculum.

Classification and distribution

Once lumped as a single genus within the Hydrobiidae, this family now has four genera: *Glacidorbis*, which occurs throughout south-eastern Australia; and *Striadorbis*, *Benthodorbis* and *Tasmodorbis*, which occur in Tasmania.



The glacidorbid snails have a simply coiled shell that is often only 2 or 3 mm across.

Habitat and ecology

Glacidorbids have been found in streams in alpine areas in Victoria and New South Wales, swamps in Victoria and in mountainous areas and at the bottom of lakes in Tasmania. They are thought to be carnivorous.

Class: Gastropoda, Family: Hydrobiidae

Distinguishing characteristics

This diverse group of small snails covers squat, rounded animals as well as relatively high spired shells. The commoner species tend to be small, dark coloured, dextrally coiled snails. Most species are smaller than 5 mm.

Possible misidentifications

Snails from the family Pomatiopsidae are very similar, but although some of the Hydrobiidae occur in estuarine locations, none have been recorded from the saline lakes where pomatiopsids are found.

The genus *Beddomeia* is very diverse. Different rivers will have different species, even if they are in the same catchment.

The New Zealand hydrobiid snail, *Potamopyrgus antipodarum,* showing its snout and the operculum that closes the shell.

Classification and distribution

Hydrobiids occur throughout south-eastern Australia. They are represented by around 12 genera and are prone to extreme local speciation. In contrast, the introduced hydrobiid snail *Potamopyrgus antipodarum* is now almost cosmopolitan. It has invaded both Europe and Australia from its homeland of New Zealand.

Habitat and ecology

The hydrobiid snails occupy a diverse range of aquatic habitats and it would not be surprising if they turned out to be just as ecologically diverse, but as yet very little work has been done on their biology. Like other groups, they can occur in huge quantities. The introduced snail *Potamopyrgus antipodarum* thrives in nutrient-rich urban and rural streams.

Natural history

The hydrobiids reproduce sexually. The females lay small bundles of eggs, sometimes in mucus and sand grain cases. Many live for longer than a year and have very restricted habitat tolerances.

Pond snails and liver fluke snails (Class: Gastropoda, Family: Lymnaeidae)

Austropeplea lessoni can be found amongst weeds in ponds and billabongs. Its broad triangular tentacles are quite distinctive.

Distinguishing characteristics

The family Lymnaeidae is distinguished by thin, dextrally coiled shells, which have a wide opening and no operculum. The shells are broad, with the first loop or body whorl much larger than subsequent turns. Sculpture, if present, is dominated by fine spiral lines. The live animals have distinctively short, triangular tentacles, with eyes at their bases. Most lymnaeids are smaller than 20 mm.

Possible misidentifications

Some members of the Physidae/Planorbidae are similar looking and occur in the same habitats, but they are coiled in the opposite direction (sinistral). Land snails from the

Nasty free-loaders

The native lymnaeid *Austropeplea tomentosa* and the introduced species *Pseudosuccinea columella* are both intermediate hosts for the sheep liver fluke *Fasciola hepatica*. Ian Clunies Ross, the famous parasitologist, unravelled the complicated lifecycle of these parasites in the 1930s. Sheep liver flukes start their life cycle as eggs, passed in faecal matter by infected animals. These eggs enter a pond, dam or small stream and once they have hatched find their first host: a lymnaeid snail. Once inside the snail, the liver fluke larva begins to mature in various organs of the unfortunate snail, until it can reproduce asexually. It then infests the snail with many genetically identical versions of itself. Eventually these second-stage larvae leave the snail and crawl from the pond or stream side, into the surrounding vegetation where they attach themselves to grass near the water's edge, waiting to be eaten by their final hosts. These hosts can include native animals such as kangaroos and wallabies, but were originally sheep. Once inside sheep, the fluke larvae travel from the intestine into the abdominal cavity, where they infest the liver and bile ducts. After a month or two the flukes mature, the adult form is from 15–40 mm in length and can do quite a lot of damage to a mammal's internal organs. Eggs from the adult flukes find their way into faecal matter and are released into or near water once again. In comparison, the snail's life is quite dull.

Austropeplea tomentosa **is thought to be an intermediate host of the sheep liver fluke.**

family Succineidae are often found near the water's edge and can sometimes fall in. They have similar shells but differ from the Lymnaeidae by having cylindrical tentacles with eyes at their tips rather than their base, and more constricted shells at the start and finish of each whorl.

Classification and distribution

Six species, from four genera are found in south-eastern Australia. The native genus *Austropeplea* has two species, *Kutikina* has one, and there are a further three species introduced from Europe and North America. The European snails are from the genus *Lymnaea* and the North American snails from *Pseudosuccinea*. *Kutikina* is a small snail restricted to sections of the Franklin River in south-west Tasmania.

Habitat and ecology

Lymnaeids are typically found in slow-flowing or still waters, grazing algae from hard surfaces. The coarse grain of their radula teeth reflects their diet of comparatively large filamentous algae. Most other snails feed on the finer algal and bacterial parts of the periphyton. Lymnaeids can survive in water with very low oxygen content by floating to the surface and filling their 'lung' with air.

Natural history

With most lymnaeids, eggs are fertilised in both partners during sexual reproduction and these are then laid in clusters, from which miniature snails eventually emerge. Most lymnaeids are short-lived but capable of self-fertilisation.

Class: Gastropoda, Family: Physidae/Planorbidae

Gyraulus tasmanicus is one of the flat planorbids that gives the family its name.

Distinguishing characteristics

The Planorbidae is a diverse family with shell shapes ranging from flat to high spired and with varying degrees of shell sculpture. Planorbids lack an operculum, and are always sinistrally coiled (opening to the left). The physids are represented by a single introduced species *Physa acuta*, which shares all these characters, but also has finger-like processes under the edge of its shell and a mottled mantle that can be seen through its translucent shell.

Possible misidentifications

The flat-shaped genera superficially resemble members of the Glacidorbidae, but differ by being larger and lacking an operculum. The genus *Ancylastrum* shares parts of its name, as well as its form, with the Ancylidae. However, it is larger than any of the Ancylidae and has ribs and a remnant of a spiral at its tip.

The introduced snail *Physa acuta* has a mottled mantle that is usually visible through the shell.

Classification and distribution

Eight genera of the Planorbidae are found in south-eastern Australia. These are: *Planorbarius*, *Isidorella, Glyptophysa* and *Bayardella*; the flat-shaped genera *Helicorbis*, *Pygmanisus* and *Gyraulus,* and the limpet-like *Ancylastrum*. The physids are represented by a single introduced species, *Physa acuta*.

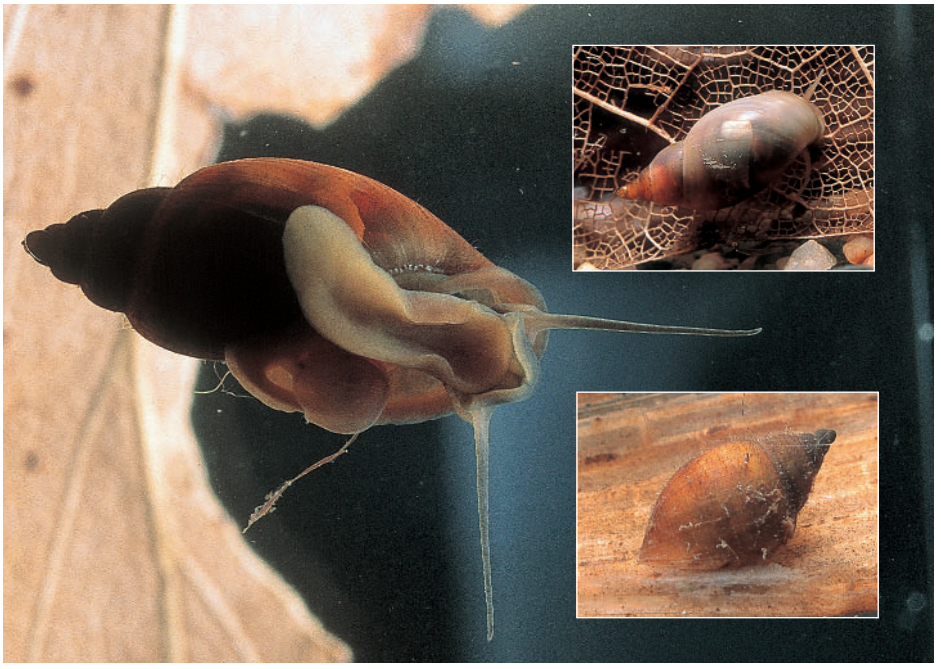
Habitat and ecology

The planorbids inhabit a diverse range of aquatic habitats, but most are from slow-moving waters. The physids are similarly distributed.

Natural history

Both the Planorbidae and Physidae are hermaphrodites—they are capable of self-fertilisation and reproduce at least once a year.

The giant limpet *Ancylastrum* is extremely rare. It used to occur throughout lakes on the central plateau of Tasmania, but the most recent records of it are from trout gut-contents in the 1980s.



Glyptophysa is a very diverse genus, with a range of shell ornamentation. The commonest species is *Glyptophysa gibbosa* (bottom right).

Salt lake snails (Class: Gastropoda, Family: Pomatiopsidae)

Distinguishing characteristics

The shells of the pomatiopsid snails are pale-coloured and chalky. They are dextrally coiled and smaller than 8 mm high.

Possible misidentifications

Snails from the family Hydrobiidae are very similar, but they do not occur in the saline lakes where pomatiopsids are found.

Classification and distribution

Two species of *Coxiella* occur in Victoria, Tasmania and South Australia. The family does not occur in other states of south-eastern Australia.

Habitat and ecology

The pomatiopsids live at the edge of salt lakes in inland south-eastern Australia.

Coxiella is easily recognised by its typically shortened spire.

Sculptured snails (Class: Gastropoda, Family: Thiaridae)

Thiarid snails are the most heavily ornamented freshwater snails in south-eastern Australia.

Distinguishing characteristics

The thiarids are one of the more ornately sculptured freshwater gastropods of south-eastern Australia. The commonest genus is adorned with a combination of ridges, grooves and raised longitudinal ribs, which make it look more like something found at the beach. Shells are dextrally coiled, high spired with a thick operculum and reach 25 mm in length.

Possible misidentifications

While some of the Planorbidae can have quite ornate shells, they are rarely as large, lack an operculum and have sinistral coils.

Classification and distribution

One genus, *Thiara* (formerly *Plotiopsis*) is quite common throughout the Murray-Darling and other inland basins.

Habitat and ecology

The thiarids of south-eastern Australia are periphyton grazers in flowing water. They persist in soft sediments and can withstand periodic drought.

Natural history

The thiarids are a very diverse group globally, with most of their diversity centred in the tropics. They are most notable for their tendency for parthenogenetic reproduction, which enables new colonies of the animal to arise from an individual.

Freshwater mites and spiders

(Class: Arachnida)

Arachnids have eight legs and highly fused body segments. Instead of having a head, prothorax, mesothorax, metathorax and abdomen, these have been simplified to a cephalothorax and an abdomen in spiders and a single body segment in mites.

Freshwater mites (Order: Acarina)

Distinguishing characteristics

Water mites are a very variable group but all have simple rounded bodies with eight legs. Their mouthparts include a pair of palps and a structure for piercing their prey called a rostrum. Some of them have swimming hairs on their legs. Some are hard bodied, while others are soft. Parasitic, juvenile forms often have six legs. Free-living adults of the larger species of mite can grow to around 5 mm.

Classification and distribution

Twenty-five families of mite occur in the freshwaters of temperate Australia. Many species are endemic, though there are also a number of cosmopolitan species. The mites found in freshwater environments tend to be widespread but patchy in their distributions.

Habitat and ecology

Aquatic mites spend varying amounts of their youth out of the water. This is because they are attached to aquatic insects as parasites. Once they have matured, mites become predatory, using their beak-like rostrum to pierce their victims. Prey includes early instar insects and microcrustaceans. Mites occur in all freshwater habitats, but are more plentiful, and diverse in slower flowing waters.

Natural history

Some of the more obvious freshwater mites in freshwaters are large, round and bright red. Unfortunately, these are not all the same and 'big red mites' come from a whole range of families such as the Eylaidae, Hydrachnidae and the Limnocharidae.

Many of the freshwater mites propel themselves through the water with their hair covered legs. This movement appears frantic, and sometimes random.

The 'big red mites' are from a variety of different families. Most of the characters needed to identify them accurately require a microscope.

In many cases this red colouration is combined with pores in the skin that secrete a distasteful substance. Larger predators such as fish soon learn to associate the bright red with an unpleasant taste and leave the mites alone. Some mites cheat and use the protective red colour without developing the toxic defences.

Non-red mites are by no means totally defenceless. Many have hard plates covered with spines and blades which offer a similarly strong disincentive to larger predators.

Nursery web spiders, fishing spiders, swamp spiders (Family: Pisauridae) and wolf spiders (Family: Lycosidae)

Distinguishing characteristics

These spiders are robust, fast-moving hunters. They have mottled colourings including grey, brown and green, sometimes with pale stripes. They are covered in fine hairs, giving them a velvety appearance. The pisaurids build a nursery web for their eggs and spiderlings and the lycosids sometimes live in silk-lined tunnels. Neither has a fixed web. Members of both the Pisauridae and Lycosidae occur in a range of sizes, with body lengths from 10–20 mm. Total length with legs can exceed 120 mm.

Fishing spiders can either have prominent stripes, or a mottled green pattern.

Possible misidentifications

The Pisauridae and the Lycosidae are very easy to confuse. The pisaurids generally have thinner legs and more mottled colourings. They are the more common of the spiders that hunt on water. Lycosids look slightly more robust and have their eyes arranged in three rows with the posterior pair considerably enlarged.

Classification and distribution

The Pisauridae is represented in south-eastern Australia by a single genus *Dolomedes*, while the Lycosidae includes several genera, which are infrequently found around freshwater.

Habitat and ecology

Both the Pisauridae and the Lycosidae hunt on or near the water surface, in spots where the water provides a ripple-free surface.

Natural history

These spiders wait beside the water with several legs touching the water surface, using it a bit like a large wet web. Struggling insects (or sometimes fish or tadpoles) send ripples through the water, which alert the

A fishing spider (*Dolomedes sp.*) uses the water surface like a giant web and will skate out and feed on anything small that causes a ripple.

spiders to their prey. Fishing spiders (Pisauridae) are able to hunt actively below the surface of the water as well. The dense hairs that give them their velvety appearance are waterproof and trap air between them, stopping the spider from becoming waterlogged. This sheet of air bubbles makes the spider very buoyant however, and if it looses its grip, it will shoot to the surface, instantly parting the surface tension.

Fishing spiders can stay submerged for up to an hour or so and this can help them evade larger predators such as birds. Although their venom is harmless to humans, fishing spiders can be quite aggressive and can deliver a painful bite simply due to the size of their fangs.

Nursery webs, built by fishing spiders, can sometimes be found amongst the vegetation near freshwater. They are usually sheets of web, forming tent-like structures, anchored to the surrounding rocks and vegetation. These structures are only ever built to house the egg sac and spiderlings. In contrast, wolf spiders often carry their young with them as a seething mass of tiny spiders on the mother's back.

Female wolf spiders carry their egg sacs with them, while they hunt.

Long jawed spiders (Family: Tetragnathidae)

Distinguishing characteristics

Long jawed spiders are distinctly long-legged, web-spinning spiders, found along the edges of most water bodies. Their abdomens are long and their jaws are very large. They spin their webs horizontally across or near water and when disturbed they leave their webs and lie along the reeds or branches that the web is attached to. Their mottled colourings and stick-like shape make them difficult to spot once they are still. Mature female spiders are slightly larger than males with a body length from 15–20 mm. Including legs, their total length is around 60 mm.

A female long jawed spider.

Classification and distribution

The Tetragnathidae (formerly part of the Argiopidae) is quite a diverse family, but only the genus *Tetragnatha* is consistently found near water. They occur throughout temperate Australia, with around 10 different species spread through different regions.

Habitat and ecology

Long jawed spiders are predators. They occur around all types of water bodies. It is thought that their horizontally slung nets are designed to snare aquatic insects and the diverse range of true flies (Diptera) associated with the water margins.

Natural history

In many types of spider, the female eats the male after they have mated (and sometimes before). Long jawed spiders are one of the few groups where the male actually escapes. The male holds the female's fangs apart and keeps them at a safe distance with his own. This is thought to be the main use for their overly large jaws. Males transfer sperm to the females with a small leg-like appendage called a palp, which is located behind the jaws. Just to be safe, these spiders have also developed very long male palps.

A long jawed spider makes a meal of a damselfly. It feeds on the winged adults of aquatic insects.

Microcrustaceans: water fleas, copepods, clam shrimp and seed shrimp

Microcrustaceans are a large group of very small animals that often turn up in samples from rivers, ponds and wetlands. Because they are so small, we only ever see their largest representatives.

Microcrustaceans are common in still water habitats such as lakes and wetlands and can be a useful indicator of water quality. They are found in sediments, as well as living free in open water. They are best collected with a very fine mesh sieve (<0.25 mm), or by taking samples of mud, vegetation and water from a site and keeping them in a fish tank. Once the sediment has settled within the tank, you can use dark and light backgrounds and a magnifying glass to hunt for them. If you have only sampled juveniles, it will take several weeks before you see anything. Most will start out life as barely visible dots moving jerkily up and down the walls of the tank.

Calanoid copepods are one of the better-studied groups of microcrustaceans. Understanding their ecology can help assess the health of the habitats they live in.

Water fleas (Order: Cladocera)

Distinguishing characteristics

The cladocerans are called water fleas because of their jerky movement and the beak-like shape of their heads. They have a simple carapace that covers the animal's body and is extended around the head. Sometimes this is extended further to form spines on either the head or the tail. The antennae are often enlarged and branched to help push the animal through the water. The eggs of mature females can sometimes be seen through the side of the carapace, lined up along the back, or in bundles on the sides.

Simocephalus sp. is one of the largest cladocerans. This individual is full of asexually produced eggs.

Some of the larger cladocerans found in wetlands can grow to a length of 5 or 6 mm. Most species, however, rarely exceed 2 mm. Some of the smaller families from this group have reduced antennae (e.g. Chydoridae) but often these animals are too small to see and are therefore not dealt with here.

Possible misidentifications

Without sufficient magnification, many of the microcrustaceans will look the same. The cladocerans are much rounder-looking than the copepods, and females keep their eggs internally rather than having distinct bundles of them attached to their abdomens—a distinctive copepod trait.

Classification and distribution

The taxonomy of the cladocerans is still unsettled but there are at least 150 species from over 40 genera in Australia.

Habitat and ecology

Cladocerans feed mainly on detritus, bacteria and algal particles, drawing them into the carapace with a current of water driven by rows of fine legs. Some are found in or near the benthos, while others are found in open water as part of the plankton community.

Natural history

Cladocerans can reproduce very quickly and this allows them to follow their main food sources: bacteria and algae. Their average life span is around one-and-a-half months and they can reproduce within one to two weeks of hatching. This rapid reproduction is usually performed asexually by parthenogenetic females. The female produces large quantities of eggs, hatches them within her carapace, and releases them during a subsequent moult.

Many cladocerans live in temporary ponds or wetlands that dry out each year and they survive these harsh, dry periods as sexually produced eggs. The female will thicken a section of the carapace known as the 'ephippium' and this protects the already resilient eggs. The eggs stay in the casing of the female after she has died and wait until the pond or wetland next fills up.

Cladoceran eggs are resistant to drying, freezing and digestive juices, and this allows them to be distributed throughout an astounding range of locations. They can be blown with fine sediments by the wind, or passed through the digestive tracts of larger animals such as birds that travel between water sources. Cladoceran eggs are also very long-lived. They have been successfully hatched from pond sediments that have been dry for 200 years.

Most cladocerans such as this *Simocephalus* sp. feed on microscopic algae and these can make the digestive tract a vivid green.

Copepods (Subclass: Copepoda)

Distinguishing characteristics

Most copepods are extremely small (less than 2 mm), with the exception of several species from the order Calanoida (around 4 mm). Their bullet-shaped bodies are made up of a head segment, which is slightly longer than the other segments, followed by a simple thorax of cylindrical segments, and a slightly thinner abdominal section. Their most striking characters are their antennae (often long), the single dorsal eye, and the bundles of eggs that mature females carry. Some species are brightly coloured, but most are a mixture of clear and brown-green.

Cyclopoid and calanoid copepods move using oar-like strokes of their antennae in open water coupled with pulses of their multiple legs, while harpacticoid copepods wriggle their bodies over surfaces.

Possible misidentifications

See Cladocera.

Classification and distribution

There are three orders of copepods: Calanoida, Cyclopoida and Harpacticoida.

Habitat and ecology

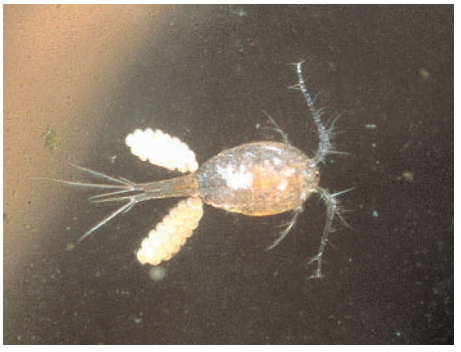
The cyclopoid and the harpacticoid copepods are both predominantly benthic, while calanoid copepods are usually planktonic. Most of them are herbivores/detritivores, feeding on algae and bacteria. Some of the larger calanoid and cyclopoid copepods are predatory, feeding on a mix of zooplankton including other smaller copepods.

Natural history

Most copepods live for less than two months and reach maturity within the first three weeks. Calanoid and harpacticoid females carry single bundles of eggs, while the cyclopoid copepods have paired egg bundles attached to their abdomens. Their antennae serve as oars propelling them through the water, but also play a role in reproduction and predator avoidance.

Male copepods have hinged antennae on one side, which are used to clasp the female during moments of passion.

Female calanoid copepods carry a single bundle of eggs in the middle of their abdomen (*Boeckella major*).



Female cyclopoid copepods carry a double bundle of eggs, which gives them a very distinctive outline.

Clam shrimp (Order: Conchostraca)

Distinguishing characteristics

Clam shrimps have a small multi-segmented body enclosed in two valves, making them look a lot like a bivalve. The body is covered densely with around 10 to 30 pairs of legs and the shell is usually sculptured with concentric growth lines. (The family Lynceidae is an exception to this.) Conchostracans come in a variety of colours, from blue to brown, or translucent forms. They can grow larger than 10 mm.

Possible misidentifications

Conchostracans are very similar in appearance to ostracods: they differ by sometimes having growth lines, usually being larger in size and by having more thoracic legs.

Classification and distribution

There are more than 20 species in Australia, but most of them are uncommon. The commonest is a large wetland genus, *Limnadopsis*, which has a distinctively ridged shell.

Clam shrimps look a lot like small freshwater mussels, but they usually have slightly more translucent shells and many more legs. This is *Limnadia* sp.

Habitat and ecology

Conchostracans occur in a variety of temporary waters. They are herbivores/detritivores, filter-feeding using a current generated by the mess of legs within the shell. Their eggs are capable of resisting desiccation through prolonged dry periods.

Inside their shells, conchostracans have a distinctly crustacean shape, including a rostrum and antennae. This is *Cyzicus* sp.

Seed shrimp (Class: Ostracoda)

Distinguishing characteristics

The bodies of the seed shrimps are totally covered by two valves of the carapace, in the same way as the less common conchostracans. Ostracod carapaces are extremely variable—they carry sculpturing such as pits or ridges and can occur in a wide variety of colours. Ostracods propel themselves with an assortment of legs and antennae, which are thrashed around in the gap between the two valves. When threatened, these appendages are retracted and the sealed shell drops to the ground. They are mostly smaller than 2 mm though there are larger species.

Possible misidentifications

See Conchostraca.

Classification and distribution

Ostracods are fairly diverse and distributed across temperate Australia in still and (to a lesser extent) flowing waters. There are around 200 described species in Australia.

Habitat and ecology

Ostracods are herbivore/detritivore filter feeders. They are commonly found on the soft sediments at the bottom of ponds and wetlands, though some species do travel in open water or even on the underside of the water surface.

Natural history

The valves of ostracods fit together well enough to allow the adults to survive short-term drying, but the eggs are more tolerant and can survive in dried sediments for several years.

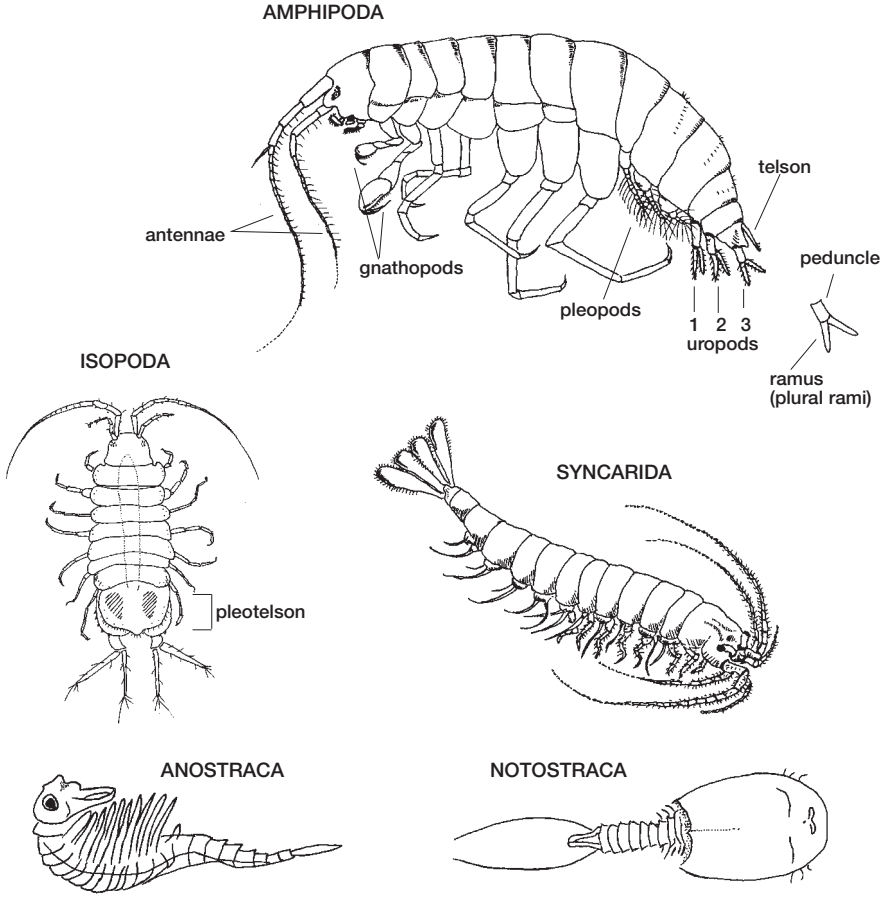
The variety of sculpturing on ostracod shells means that it is sometimes possible to identify them from their shell alone. This fact, coupled with the way that the old shells of dead animals can collect in layers under wetlands like shells on a beach, has helped scientists discover how ostracods lived in wetlands thousands of years ago. Each of the ostracods has a set range of conditions that it can live in, including temperature, salinity and acidity. Knowing these tolerance levels allows scientists to make estimates of past climates from the different collections of ostracod shells that they find in wetlands.

Some ostracods are light sensitive. The tiny lens on the side of their shell covers a simple eye.

Ostracods move using an assortment of legs and antennae. Several of these can be seen outside the edges of their shell. The light spots in the centre of the shell show where the muscle that closes the shell is attached.

Assorted crustaceans: amphipods, isopods, syncarids, brine shrimp and tadpole shrimp

Primitive crustaceans tend to have more legs than those that have evolved more recently. Syncarids, brine shrimp and tadpole shrimp all have numerous pairs of legs and closely resemble their geologically ancient ancestors found as fossils around the world.



These crustaceans are grouped together because of their similar overall structure. Amphipods are by far the most common, followed by the isopods. Syncarids are encountered in Tasmania, brine shrimps (Anostraca) are found in inland saline pools and wetlands, and tadpole shrimps (Notostraca) occur in wetlands all over the continent.

Side swimmers or scuds (Order: Amphipoda)

Distinguishing characteristics

Amphipods are laterally compressed (flattened from the sides) and, when resting, have a rounded profile. They have relatively short bodies, with seven pairs of walking legs followed by three pairs of small, feathery swimming limbs known as 'pleopods'. They have two pairs of antennae and a pair of eyes made up of several smaller eyespots. They come in a variety of colours, from light greens and greys to reds and blues. Amphipods vary in size, from about 5 to 25 mm.

Possible misidentifications

See Isopoda.

Classification and distribution

Seven families of amphipods are found throughout the inland waters of south-eastern Australia. The Talitridae occur in-frequently, as they live on the edges of water and are sometimes sampled after they fall or are washed into streams. The Ceinidae and Eusiridae are common throughout, usually being represented by the genera *Austro-chiltonia* and *Pseudomoera* respectively.

Male amphipods lock themselves to their partners during mating. The female is the smaller of the two. (Family: Paracalliopiidae).

Talitrid amphipods spend most of their time on land but near water, so they are sometimes washed into rivers.

Sometimes ceinid amphipods can be orange, this one is from a drying wetland (*Austrochiltonia* sp.).

Ceinid amphipods are usually green, and live amongst water plants. Females carry their eggs under a set of plates between their walking legs. This is *Austrochiltonia* sp.

The eusirid amphipod *Pseudomoera* sp. is one of the commoner amphipods in Victoria.

Corophium sp. is found in some estuaries in Tasmania. Most of the members of this family have muscular antennae for gathering food.

Amphipods spend much of their time upside down and sideways (*Antipodeus* sp. Family: Paramelitidae).

Neoniphargids resemble paramelitids, but they occur in odd habitats like buttongrass ponds, alpine streams, and small coastal streams.

The corophiids are found in some coastal streams of Tasmania and Queensland, so they might turn up in coastal New South Wales and Victoria. The paramelitids are fairly widespread, with four genera in south-eastern Australia, the commonest being *Austrogammarus*. The Neoniphargidae and Paracalliopiidae are less common. The neoniphargids are a diverse group, with seven genera from south-eastern Australia. They occur in a variety of odd habitats including caves and crayfish burrows. When they do occur in streams, they turn up in trickles and very small headwater streams. *Paracalliope*, the only genus of the Paracalliopiidae, occurs in Tasmania and possibly in Victoria.

This family is sometimes grouped with the Eusiridae. It can be found in buttongrass ponds and small alpine lakes.

Habitat and ecology

Most Australian amphipods are found in still to slow-moving waters. They are all omnivorous, feeding predominantly on decaying vegetation though they will opportunistically feed on other animals. They are usually shredders, but can use a range of feeding methods including filter feeding and grazing. The Corophiidae and the Ceinidae are typically found in slightly more saline waters (often coastal) than amphipods from the other families.

History

In the Cretaceous period (around 90 mya) global temperatures were around 10°C warmer and the sea covered large areas of inland Australia, reducing south-eastern Australia to two large islands: the Great Dividing Range and Tasmania. Large tracts around the South Australian border with Victoria and in Gippsland were reduced to low-lying swamps. The freshwater amphipods were restricted at this stage. Later, as the sea receded, salt-tolerant groups, such as the ancestors of the Ceinidae and Eusiridae, filled in the gaps in the freshly uncovered river systems, while the primitive freshwater amphipods (Neoniphargidae and Paramelitidae) were stranded in the mountainous parts of south-eastern Australia.

Natural history

Male amphipods guard their mates closely, locking themselves to their partners with their second gnathopods (claws). In these pairs, the smaller animal is the female. Females lay eggs after they have moulted, so males couple with females before they moult, mate with them, and then guard them until fertilisation is complete. Once fertilised, the eggs hatch and the juveniles undergo a few moults within the female's marsupium (a set of plates that cover the eggs), before being released into the outside world when the female next moults.

Key to the families of amphipods

1	second antennae much longer than first	**Talitridae**
1	first antennae longer than second, or antennae equal lengths	**2**
2(1)	live animals green, or sometimes orange; telson elevated by fleshy triangle, third uropods strongly reduced, without rami	**Ceinidae**
2	live animals not green or orange, other characters not as above	**3**
3(2)	seventh leg very long, longer then sixth, final segment long and hairy, can break off (Tasmania only, buttongrass ponds, sometimes estuaries)	**Paracalliopiidae**
3	seventh leg not much longer than others	**4**
4(3)	live animal has lateral stripes, or with a darker middle band; both rami of third uropod a similar size; accessory flagellum of first antennae minute or absent	**Eusiridae**
4	live animal uniformly coloured, grey to fawn; inner ramus of third uropod smaller than outer or absent	**5**
5(4)	animal slaty black-grey, with a matt finish, slightly compressed dorso-ventrally; only found in or near estuaries; telson entire	**Corophiidae**
5	animal colour grey to fawn, animal not dorso-ventrally compressed, surface shiny; never in estuaries; telson cleft or notched	**6**
		(anonymous grey amphipods, microscope required)
6(5)	sternal gills sausage-shaped or absent (fairly common)	**Paramelitidae**
6	sternal gills dendritic (found in sphagnum bogs, crayfish burrows, and caves)	**Neoniphargidae**

NB: Amphipods are arranged within this key in order of difficulty. The last three families are almost impossible to separate without a microscope.

Water slaters or sow bugs (Order: Isopoda)

Distinguishing characteristics

Isopods are usually dorso-ventrally compressed (flattened from above) and generally resemble their best-known representative, the garden slater or woodlouse. The phreatoicids are an exception to this rule and they look more like over-stretched amphipods.

Possible misidentifications

Although many isopods are dorso-ventrally compressed (flattened from above), the phreatoicid isopods have quite flat sides and this can make them look like amphipods. Phreatoicids are usually more elongate than amphipods and have their final segments fused together to form a pleotelson. (See figure, page 68.)

Classification and distribution

Four suborders of Isopoda are found in the inland waters of south-eastern Australia. The Asellota is represented by a single family, Janiridae, with a single genus *Heterias*. These animals are quite common in lowland, slightly saline systems and are quite distinctive in appearance. The Flabellifera is a group of parasitic animals, from large lowland rivers such as the Murray.

The Oniscidea is represented by two families: Oniscidae and Styloniscidae. The Oniscidae is represented by a single genus, *Haloniscus*, which occurs in saline lakes, while the Styloniscidae is a predominantly terrestrial group with a few amphibious members from billabongs and ponds along the lower Murray River and some rainforest streams in Tasmania. The Phreatoicidea is a diverse group, with families present in a variety of cryptic habitats. Most of the Isopoda of inland waters occur in lowland systems, where salinities are slightly higher. The suborder Phreatoicidea is an exception, occurring in a variety of streams in Tasmania and in a number of odd habitats throughout south-eastern Australia including: sphagnum bogs, crayfish burrows, tarns, caves and ground waters.

Habitat and ecology

Most isopods are detritivores, shredders of leaves and other organic matter, although there are some notable exceptions: two families of isopod from the suborder Flabellifera are parasitic. The cirolanids are ectoparasites of freshwater shrimp and the sphaeromatids can be parasites on freshwater fish.

The janirid isopods have a distinctly rounded final abdominal segment (*Heterias* sp.).

The sphaeromatids are quite common in the estuarine parts of rivers.

Some isopods are parasitic on other crustaceans. The cirolanids attach themselves to freshwater shrimp and prawns with their strongly hooked legs.

The phreatoicid isopods are a diverse freshwater group. Common stream genera include *Uramphisopus* and *Colubotelson*.

Syncarids (Superorder: Syncarida)

Distinguishing characteristics

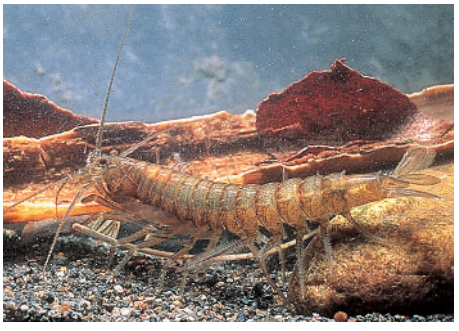
Syncarids look a bit like a cross between a shrimp and a millipede. They are distinctive in their lack of a carapace (fused segments), together with the presence of small leg-like processes (exopodites) on each of their walking/swimming legs. There are two commonly encountered families: the anaspidids have their eyes on stalks, while the koonungids have simple eyes which sit flush with their first body segment. Most of the syncarids are fairly small (<20 mm), though the mountain shrimp (*Anaspides* sp.) can grow to around 50 mm.

Possible misidentifications

Syncarids superficially resemble freshwater shrimp, but they lack the fused segments at the front of the body which form a carapace in shrimp and other decapods.

Classification and distribution

Within the superorder Syncarida, there are three orders: Palaeocaridacea, Bathynellacea and Anaspidacea. The order Palaeocaridacea was last recorded from the Carboniferous (320 mya) and is now extinct. The order Bathynellacea occurs underground, in caves and groundwater throughout south-eastern



The mountain shrimp, *Anaspides tasmaniae* is common in high altitude streams in Tasmania.

Anaspides also occurs in streams underground. This animal is from Exit Cave.

Allanaspides sp. is only found in small ponds amongst the buttongrass heath of south-western Tasmania.

Koonunga is a small syncarid found in streams near groundwater springs.

Australia and worldwide. Two families from the order Anaspidacea (Stygocarididae and Psammaspididae) also occur in caves and groundwater, while the Anaspididae mainly occurs in Tasmania and the Koonungidae in Victoria and in Tasmania. These two families occur in surface waters.

The most commonly encountered members of the Anaspididae are *Anaspides*, which live in the pools of Tasmanian mountain streams. Their close relatives *Paranaspides* occur on the bottom of several large lakes in Tasmania and their 'little brothers', the *Allanaspides*, occur in buttongrass ponds in south-western Tasmania, often in or around the entrances of crayfish burrows (*Parastacoides* sp.). Of the Koonungidae, only *Koonunga* is occasionally found in Victorian and Tasmanian rivers.

Habitat and ecology

The syncarids are predominantly freshwater animals, despite their marine ancestry. Many of them occur in caves and in ground water amongst coarse gravels, so they are not often encountered. Several members of the order Anaspidacea are, however, quite common in Tasmanian mountain streams or buttongrass ponds. All of the members of the superorder Syncarida are thought to be detritivores, but there are cases of *Anaspides tasmaniae* feeding on insects caught on the water surface of lakes.

Natural history

All members of the Bathynellacea occur underground, in caves and groundwater. Their name, roughly translated from the Greek, refers to the 'merciless depths' at which they are found.

Anaspides come in a wide range of colours, despite there only being two species. Specimens vary through white, yellow and pink, to brown and black. To some extent this seems to be related to their surroundings. Some of the darker animals come from pools on the Tarn Shelf (Mt Field National Park), where the rocks and decomposing vegetation in the pools are all darkly coloured.

Fairy shrimps, brine shrimps or sea monkeys (Order: Anostraca)

Distinguishing characteristics

The two most striking characteristics of the anostracans are their mess of feathery legs and the fact that they swim upside down, with their legs uppermost. The saline species (brine shrimps) are usually a pink colour and are fairly small (<10 mm) while the freshwater species (fairy shrimps) are much larger (<50 mm) and pink to cream.

Possible misidentifications

Some of the larger species could be mistaken for amphipods, but the anostracans have a long thin tail section, which gives them a very distinctive appearance.

Classification and distribution

Two genera of Anostraca are present in the inland saline waters of south-eastern Australia. One, *Artemia,* is introduced while the other, *Parartemia,* is native. A single diverse genus, *Branchinella,* with around twenty species, occurs in temporary ponds and wetlands throughout the continent.

Habitat and ecology

Artemia and *Parartemia* inhabit temporary saline lakes. They lay drought-tolerant eggs, which hatch after they have been saturated in water. The animals develop quickly and soon mature to lay further eggs in the soft sediments at the bottom of saline lakes. As the waters dry up the adults die, leaving the next generation to spend the dry times as microscopic eggs.

Branchinella, the slightly larger wetland species, employs a very similar lifestyle but not at the same intense salinities. All anostracans are filter feeders.

Natural history

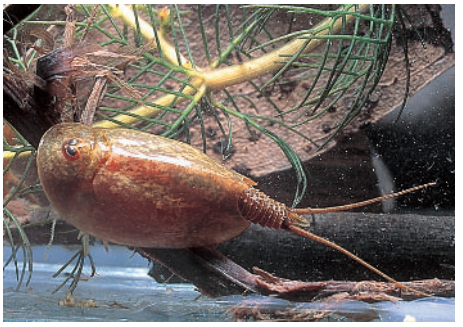
The introduced fairy shrimp *Artemia salina* now dominates many of our coastal saltpans. It is thought to have escaped from aquaculture and hobby aquariums, where it is commonly used as fish food.

Anostracans swim upside down, the pulses of their many legs pushing them forward.

Tadpole shrimp or shield shrimp (Order: Notostraca)

Distinguishing characteristics

The front half to two-thirds of the body of these animals is a long shield, which covers the thorax of the animal. The shield carries a pair of compound eyes, followed by a small lump, which is a nuchal organ (the equivalent of a nostril for burrowing-aquatic animals). Tadpole shrimp are usually brown coloured, with up to 60 pairs of legs on their underside, which propel them powerfully but often spirally. Fully grown animals can reach around 40 mm (body length without tails).



The carapace of the tadpole shrimp (*Lepidurus apus viridis*) has a small nuchal organ just behind the eyes. It works a bit like a nostril.

Classification and distribution

Two species occur in temperate Australia. The commonest is *Lepidurus apus viridus*, but *Triops australiensis australiensis* also occurs along the New South Wales/Victorian border and in parts of Western Australia. *Lepidurus* has a short plate projecting between its two tails, while *Triops* has a flat end to its abdomen.

Habitat and ecology

Notostracans occur in wetlands that dry out from time to time. Their eggs are drought tolerant and are activated by the presence of water, not unlike those of the Anostraca.

Both species found in south-eastern Australia are thought to be detritivores. They forage and live in the soft sediments of wetlands.

Natural history

Lepidurus apus viridus tends to be found in spring in south-eastern Australia, while *Triops australiensis australiensis* is an autumn animal. The adults live for about a month, in which time they mate and lay their microscopic eggs in the sediments. These animals tend to disappear from wetlands that remain inundated for a long time, but they return after a dry period.

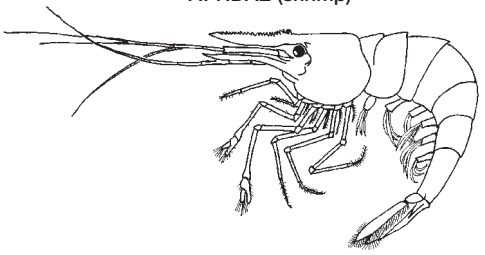
The tadpole shrimp (*Lepidurus apus viridis*) has around 60 pairs of legs. Some of the anterior pairs have pincer-like ends.

The tadpole shrimp (*Lepidurus apus viridis*) wriggles free of its old skin, through a gap behind its head shield.

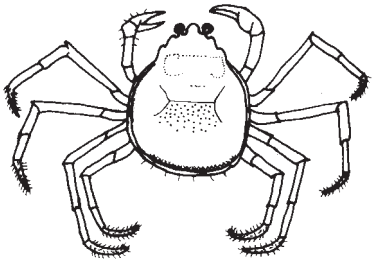
Freshwater shrimp, prawns, crabs and crayfish (Order: Decapoda)

Decapods are usually large, highly mobile animals. They are often the largest invertebrates in a stream and as a result are an important part of the food chain.

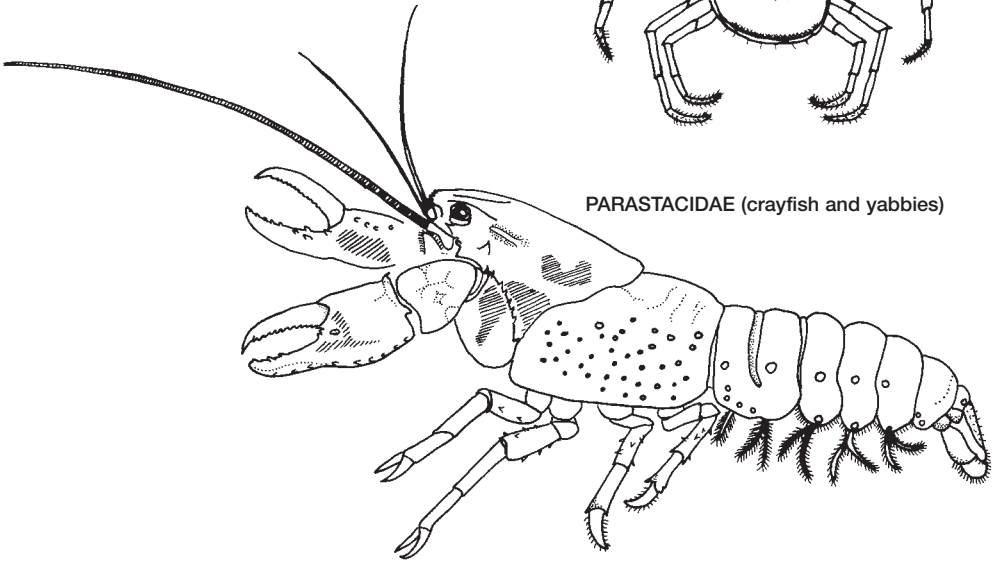
ATYIDAE (shrimp)*



HYMENOSOMATIDAE (false spider crabs)



PARASTACIDAE (crayfish and yabbies)



*Note: Palaemonidae (prawns) are similar to Atyidae (shrimp) but have long, robust second legs.

Characteristics of a decapod crustacean

The most distinctive features of decapods are their stalked eyes and their 10 legs. In many, this includes at least one pair of legs with pincer-like endings (chelae), though the Atyidae sport a pair of brushes as well. The smaller and finer limbs in front of the legs are mouthparts and antennae, while those behind the legs are known as pleopods and may help the animal to swim.

Eating and extinction

Prawns, shrimp, yabbies and crayfish feature in our cuisine. Various species of the palaemonid prawn *Macrobrachium* are cultured in large ponds throughout Asia, while the Atyidae feature in a range of shrimp-based dishes. In Australia, the yabby is popular with aquaculturists, along with the marron and the gilgie (also from the genus *Cherax*). These animals mature quickly and reach an edible size within two years. Of the larger crayfish with harder exoskeletons, the genera *Euastacus* and *Astacopsis* include a number of species that have been extensively fished over the last century. This has led to several species becoming endangered, as the compound effects of overfishing, habitat degradation and worsening water quality have taken their toll. Most of these larger freshwater crayfish are quite slow growing and can take up to nine years to reach maturity. Larger specimens (around a kilogram in weight) can be upwards of 15 years old. Their slow growth rate makes these animals very susceptible to overfishing. Fortunately, many of these species are now protected.

The Glenelg crayfish, *Euastacus bispinosus,* has suffered a serious decline in numbers as a result of overfishing.

Marine invaders

Crustaceans were originally a marine group of animals so many of our freshwater decapods resemble their not-so-distant cousins from the sea. The lower salinities of

Key to the families of Decapoda

1	main body of animal flat and round, length similar to width, tail folded under and inconspicuous ..... **Hymenosomatidae** (p. 81)
1	main body longer than wide, animal with a distinct tail **2**
2(1)	robust animals, with front claws much more robust than other legs ..... **Parastacidae** (p. 82)
2	delicate animals, front claws slender, not much thicker than other legs; if robust claws are present, they are the second rather than first pair of legs **3**
3(2)	second pair of legs long, and strongly chelate (with pincers) ..... **Palaemonidae** (p. 81)
3	front legs chelate, but with brushes ..... **Atyidae** (p. 80)

Level-headed crustaceans

Most decapods have a pair of sensory organs called statocysts, which work a bit like our inner ears to keep the animal upright. The base segments of the first antennae have a pore, the inside of which is lined with lots of small sensory hairs. This tiny chamber also contains a small structure made from sand grains, called a statolith. When the animal is horizontal, the statolith sits squarely on a set of hairs in the base of the statocyst. If the animal is tilted (during swimming, or while climbing banks), the statolith moves onto a different set of sensory hairs, which warns the animal that 'up' is now in a different direction. The whole system helps with navigation in waters that can sometimes become very murky. When decapods shed their skins, they lose their statoliths and have to get new ones. Some decapods do this by rubbing their antennal bases in sand while the new skins are still soft, while others are actually capable of carefully putting new sand grains into the pores with their smaller pincer legs.

A pair of sensory organs at the base of the first antennae helps to keep decapods upright.

freshwater have meant that freshwater decapods possess a very different physiology to their marine ancestors, and have adapted their lifecycles slightly. Marine decapods often have a long-lived planktonic stage, where the young drift off to sea and wash up (sometimes years later) on a different bit of coast to their parents. In rivers, a long-lived juvenile would end up lost at sea, so most freshwater decapods have given up their planktonic ways and the young start life as smaller versions of their parents, complete with claws and strong legs. In south-eastern Australia the decapod invasion has continued a little further, with many of the crayfish coming up onto land and in some cases building themselves permanent homes within it.

Environmental significance

Decapods occur over a wide range of water qualities. Some preferring slightly saline conditions, while others occur in mountain streams. This makes their general presence a little ambiguous when monitoring water quality. The distributions, biology and environmental tolerances of many species of the Parastacidae are well studied, however, and they can be useful indicators of stream degradation at the local scale.

Classification and distribution

The order Decapoda is represented in the freshwaters of temperate Australia by four major families, Parastacidae (crayfish), Palaemonidae (prawns), Atyidae (shrimp) and Hymenosomatidae (false spider crabs). A simple key to the families of decapods in south-eastern Australia appears opposite. Two extra families, Grapsidae and Sundathelphusidae, that are strongly related to the marine shore crabs, occur in tropical Australia. The palaemonids do not occur in southern Victoria or Tasmania.

Freshwater shrimp (Family: Atyidae)

Distinguishing characteristics

Atyids are translucent and can be mottled with blues, greens and darker markings. Stressed or dead animals become opaque and either white or pink, like cooked prawns. The front two pairs of legs of the atyids bear distinct brushes. Most members of this family are around 2–4 cm when fully grown, but some of the cave-dwelling genera are slightly smaller.

Possible misidentifications

Damaged animals lacking the front two pairs of legs might superficially resemble the Palaemonidae or even young yabbies. Both of these families are usually more robust than the Atyidae and are also less translucent.

Classification and distribution

Two genera of Atyidae occur in south-eastern Australia. *Paratya* has one species, *Paratya australiensis*, the commonest freshwater shrimp in temperate Australia. The genus *Caridina* has eight species but these animals are less common than *Paratya australiensis*. They do not occur in Tasmania.

The freshwater shrimp *Paratya australiensis* has its front two pairs of legs ending in fine brushes.

Habitat and ecology

Atyids occur in the slower flowing (lowland) rivers and in ponds and billabongs. They feed mainly on detritus, fine decomposing vegetation, bacteria and algal particles, pulling them into their mouthparts with the brushes on the first two pairs of legs.

Natural history

Paratya australiensis benefits from the seasonal drying of many of the rivers it occurs in. As the rivers is reduced to a series of poorly connected pools, it starts to breed. Atyid shrimp have a planktonic stage for the first months of their lifecycle. The small and fragile young grow up over summer in the sheltered pools and by the time the river starts to flow again in spring, they are developed enough to handle the river currents.

Female shrimp carry their eggs under their abdomen. The pleopods keep a flow of fresh, oxygenated water passing over them.

Freshwater prawns (Family: Palaemonidae)

Distinguishing characteristics

Palaemonids have their second pair of legs much longer than the first and these end in a robust set of pincers. Their bodies are translucent to opaque with darker brown to blue markings. They are usually slightly larger than the Atyidae and can measure around 6–7 cm when fully grown, sometimes with claws the same size again.

Possible misidentifications

Young, or damaged specimens can resemble Atyidae. Check the front two pairs of legs.

Classification and distribution

One genus, *Macrobrachium,* is common in temperate Australia. Several species occur in New South Wales, northern Victoria, Western Australia and South Australia, the most common being *Macrobrachium australiense*. While the freshwater palaemonids do not occur in southern Victoria or Tasmania, their estuarine relatives can sometimes be found in the lower ends of rivers.

Habitat and ecology

Palaemonids are scavengers that feed on a mixture of decaying plant and animal material. They use their first and third pairs of legs, reserving their second, enlarged pair for self-defence and settling territorial disputes. They occur in lowland rivers, ponds and billabongs and are usually associated with snags or vegetation.

Palaemonid prawns (*Macrobrachium* sp.) have a very long second pair of claws. They feed with the first pair, which are much shorter.

Natural history

The family Palaemonidae includes a number of common marine genera as well. The common rock pool shrimp (*Palaemon* spp.), and red-clawed shrimp (*Palaemonetes* spp.), can be found in inter-tidal rock pools and are common in sea grass and in estuaries.

False spider crabs (Family: Hymenosomatidae)

Distinguishing characteristics

The hymenosomatid crabs have a distinctive, round shape when viewed from the top. Their front legs are modified to form pincers. They are usually brown to grey, often with a fine covering of algae on their carapaces. They grow to around 2 cm.

Classification and distribution

One genus, *Amarinus,* is found in freshwater throughout south-eastern Australia.

A pair of freshwater crabs (*Amarinus lacustris*) settle a dispute.

Habitat and ecology

Amarinus lacustris lives in a variety of habitats from slightly saline streams to lakes. It feeds on detritus and can be found in large numbers on snags in some lowland streams, or under and around rocks in lakes.

Natural history

Other crabs from the genus *Amarinus* commonly occur in estuaries, suggesting that this is perhaps where the ancestors of these freshwater crabs started out. *Amarinus* is Greek for 'not from the sea', referring to its estuarine habits. The name is perhaps more relevant for the freshwater species. The name '*lacustris*' refers to the lake habitats in which the first specimens were found.

Freshwater crabs' legs end in a pointed segment which makes them excellent climbers. They are sometimes found on woody debris in lowland rivers (*Amarinus lacustris*).

Freshwater crayfish and yabbies (Family: Parastacidae)

Distinguishing characteristics

The parastacids have their front legs modified to form robust claws. The following four pairs of legs are attached to the main carapace, which is followed by a multi-segmented abdomen ending in a tail fan.

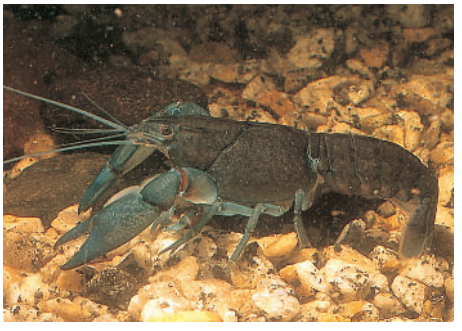
Classification and distribution

The parastacids occur throughout south-eastern Australia, with 7 genera and around 80 species (more are likely as the taxonomy of various groups is revised).

Habitat and ecology

Parastacids occur in a wide variety of habitats including swiftly flowing streams, billabongs and some even build semi-terrestrial burrows. Crayfish are by far the largest invertebrates in freshwater systems. They are omnivorous, feeding on a range of rotting vegetation, together with fish and other aquatic animals that stray too near.

Astacopsis gouldi, the world's largest freshwater crustacean, comes from Tasmania.



Cherax destructor is one of the commonest crayfish in south-eastern Australia.

Engaeus sp. is found throughout south-eastern Australia. It makes its burrow near a creek.

Natural history

Although they prefer to be under water, yabbies (*Cherax* genus) are one of the few large crustaceans able to survive the regular Australian phenomenon of drought. Many yabbies can aestivate, which involves slowing down their metabolisms and burying themselves deep in moist sediments to keep their gills from drying out.

Burrowing crayfish (genera: *Geocharax*, *Engaeus*, *Gramastacus, Cherax* and *Parastacoides*) employ a similar trick. They burrow into the soil in damp areas such as swamps, or the banks of rivers. Often the excavated soil is piled around the entrance of the burrows forming a distinctive chimney. The tunnels of burrowing crayfish often have many branches, some of which are totally filled with water. The inhabitants eat the vegetable matter they encounter while burrowing (predominantly roots) and the odd uncovered worm. Some are nocturnal and will leave their burrows to forage at night.

The Murray River crayfish (*Euastacus armatus*) has a medieval assortment of spines.

The ‘chimney’ at the entrance to the home of a burrowing crayfish. [Photo: Niall Doran]

Springtails (Class: Collembola)

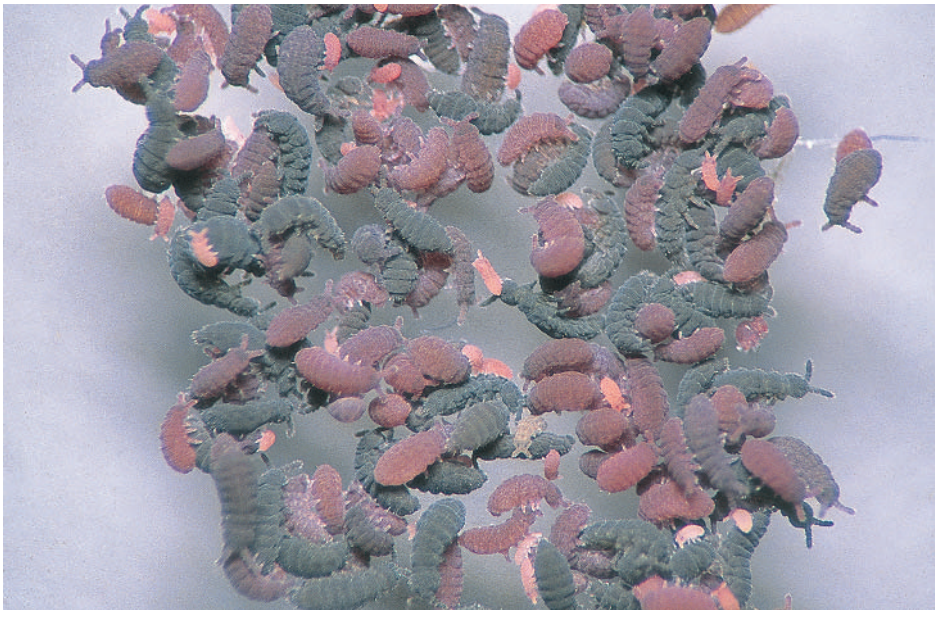
Springtails look like tiny insects and were once regarded as a primitive insect group. However, these soft-bodied invertebrates have now been placed in a separate class.

Distinguishing characteristics

Springtails are minute animals, rarely larger than 3 mm long. They vaguely resemble insects as they have a head with a pair of antennae, a thorax with three pairs of legs and a segmented abdomen. However, they have soft bodies without a hard exoskeleton and they lack wings. Unlike insects, they have a forked spring-like appendage (furcula) attached to the underside of the abdomen. This spring is held under tension by another appendage, which acts as a trigger. When the 'trigger' is released the 'spring' catapults the animal, often as far as 30 cm. Springtails can jump so quickly that they seem to disappear in front of your eyes. Springtails also have another appendage attached underneath the body but nearer the head. It was believed that this appendage helped them stick to the surface (hence the name Collembola, from the Greek *colle*, glue, and *embolon*, piston) but it is also involved with excretion and internal water balance.

Possible misidentifications

Springtails may resemble the juveniles of some insects but their unique forked spring should be enough to separate them.



Rafts of springtails like this can be a common sight after summer rains.

Collembola have a large number of insect characteristics, but their obvious spring organ and their soft wrinkly skin allow distinction.

Classification and distribution

Although the class Collembola is one of the most widely distributed groups of invertebrates, with more than 1600 species known in Australia, the only exclusively freshwater aquatic species of springtails in Australia belong to the genus *Sminthurides* (Family: Sminthuridae, Order: Symphypleona). One of the more common groups that can be washed into watercourses is the family Hypogastruridae. Members of this family are generally found in leaf litter and soil but are often washed into streams in large numbers by rain and form the 'grey rafts' sometimes seen in puddles.

Habitat and ecology of aquatic forms

Many species of springtails have an affinity for moist conditions and live at the edges of aquatic habitats where humidity approaches saturation. Most of the springtails found in rivers and ponds are washed by rain into drainage waters. The fully aquatic genus *Sminthurides* grazes on diatoms on the water surface, while most other collembola feed on fungi and on decomposing organic matter.

Natural history

The waterproof skin of most springtails prevents them from getting waterlogged and allows them to float. Terrestrial springtails may use running water as a highway to disperse and occupy new habitats. Most springtails reproduce sexually. Males deposit sperm sacs on the water surface, which are picked up by the females.

During the hot and dry Australian summer springtails burrow into the soil and lower their metabolism. During this period they do not feed. In autumn, a range of environmental cues brings them back to the surface layers of soil to feed and reproduce. During this time, the autumn rains wash a large number of them into the water.

In the northern hemisphere large numbers of springtails migrate long distances over snow during early spring. Triggered by rising temperatures, they emerge from the deep snow and follow the movements of the sun on their voyage.

Aquatic caterpillars (Order: Lepidoptera)

Caterpillars—the larvae of moths and butterflies—are a diverse and widely distributed group, so it is not surprising that some of them have managed to successfully adapt to freshwater habitats.

Distinguishing characteristics

Aquatic caterpillars come in several forms, but the most commonly encountered species are portable case builders in dams, billabongs and slow-moving rivers. These animals have fleshy bodies, short, segmented legs and a sclerotised head capsule. They are often covered in gills and these can be simple or bear multiple branches. The underside of the abdomen usually has a couple of rows of stocky pro-legs, ending in circles of small hooks or crochets. The cases are coarsely stitched (compared to most caddis cases) and incorporate large flat pieces of leaf, or lots of longitudinal pieces of finer weeds. Some aquatic caterpillars prefer fast-moving water and correspondingly adopt a very different form. These animals are robust, slightly flattened animals, often with gills. They build a silken retreat attached to stones within the stream. Most aquatic caterpillars grow to less than 20 mm long. Adults are small triangular moths with grey-brown and cream patterned wings.

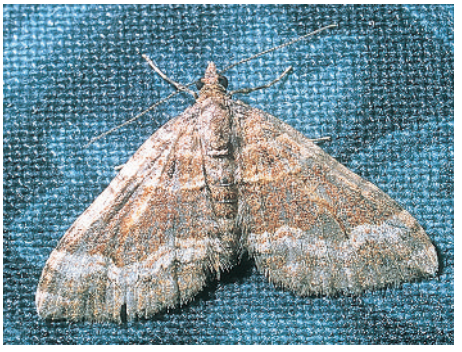
Possible misidentifications

Aquatic caterpillars share many of their characteristics with beetle larvae, but these lack the abdominal pro-legs of caterpillars, with their circles of crochets or small hooks. Riffle-dwelling lepidopterans could also be confused with some of the uncased caddis larvae such as hydropsychids, but these animals also lack crochets and their heads are much less broad.

Classification and distribution

The aquatic caterpillars all belong to the family Pyralidae and the subfamily Nymphulinae. There are around 50 species from 15 genera, but the taxonomy—particularly of the larvae—is still in progress. These groups tend to be more diverse in the tropics.

Sometimes aquatic caterpillars will use air-filled aquatic plants in their cases and this makes them buoyant.



Adult pyralid moths have broad, triangular wings which are often patterned.

The riffle-dwelling caterpillar (inset) shares many of the characteristics of its slow water relative.

Habitat and ecology

The aquatic caterpillars inhabit two very different environments. Cased caterpillars live in pools, ponds, lakes or billabongs, at low altitude, where they eat aquatic plants. In contrast, the fast water caterpillars are often found in cold alpine streams, where they feed on algae from the surface of rocks.

Natural history

Living in freshwater is thought to be a recent evolutionary step for caterpillars and there is some evidence for this in the northern hemisphere where a number of species live a semi-aquatic existence. These animals have cases that act like scuba tanks and contain sufficient air for the caterpillars to survive underwater for prolonged periods of time. In most of the Australian slow water species, this contraption is no longer necessary due to their efficient gills, but it still serves as camouflage and protection from predators. Young larvae lack cases and live as leaf miners.

Scorpionfly larvae (Order: Mecoptera)

Larger, terrestrial members of this order of insects hold their abdomens with a distinctly scorpion-like posture and this is where they get their name.

Distinguishing characteristics

Scorpionfly larvae are small slender animals with a rectangular sclerite on their first thoracic segment. The rest of their body segments are pale but shiny and slightly hydrophobic. They have short jointed legs on their first three segments, and a pair of simple hooks and a couple of gill filaments on their final segment. They move with strong snake-like motions and their legs are mainly used for grasping prey. Larvae can grow to about 15 mm long. The adults can be found on vegetation near streams in spring. They have two pairs of coarsely veined wings and a bulbous end to their abdomen.

Possible misidentifications

Scorpionfly larvae superficially resemble the ceratopogonids (see page 119) in their body shape and movement; but the legs are a dead give-away.

Classification and distribution

Most scorpionflies are terrestrial. A single aquatic family, the Nannochoristidae, occurs in Australia, New Zealand and South America. A single genus, *Nannochorista*, with three or four species, occurs in temperate Australia.

Habitat and ecology

Scorpionfly larvae are fast-moving predators of other invertebrates in silty environments. They occur more commonly in small cool streams, either in silt deposits at the sides of streams, or in silt-filled seeps and puddles beside the main stream.

Scorpionfly larvae are fast-moving predators, but the adults (inset) have simple mouthparts, suggesting that they have a liquid diet.

Because of its long thin body, a scorpionfly larva is sometimes mistaken for a biting midge larva.

Natural history

Scorpionfly larvae move using their bodies in a snake-like motion. This propels them quickly through the relatively thick silt in which they live. They are highly sensitive to movements that disturb the silt and respond quickly to the frantic movements of common prey such as chironomid larvae.

Toebiters (Order: Megaloptera)

Some of the largest freshwater invertebrate predators belong to this fearsome group of insects. They are quite common in the cobble streams of mainland south-eastern Australia.

Distinguishing characteristics

Megalopteran larvae are robust animals, with heavily sclerotised heads and thoracic segments. Their abdominal segments are fleshy and have long filaments on either side. Their legs are robust and jointed and their abdomen ends in either a single, hair fringed filament (alderfly larvae, Family: Sialidae), or a pair of clawed pro-legs (dobsonflylarvae, Family: Corydalidae). Sialid larvae grow to around 20 mm and the corydalid larvae to around 30 mm. The adults are large ponderous animals with translucent, spotty wings.

Possible misidentifications

Whirligig beetle larvae (Family: Gyrinidae) have very similar lateral filaments, but they have filaments on all 10 abdominal segments and are quite sleek, while the corydalids only have them on eight segments and the sialids on seven (not including the terminal filament).

Classification and distribution

The family Corydalidae is represented by three genera and seven species in temperate Australia. One of these genera, *Apochauliodes,* is restricted to southern Western Australia, while *Protochauliodes* and the commoner *Archichauliodes* are distributed throughout south-eastern Australia. Corydalids do not occur in Tasmania.

Sialidae is represented by two species, *Austrosialis ignicollis* in Tasmania and *Stenosialis australiensis* in south-eastern Australia.

Corydalids are large predators amongst the cobbles of fast-flowing streams.

Sialids have a single filament at the end of their abdomen.

Habitat and ecology

Both the corydalids and the sialids are predators. Corydalids live in fast-flowing waters amongst cobbles and pebbles; sialids are a slow water animal typical of pools.

Natural history

The New Zealand toebiter *Archichauliodes diversus* is intriguing in its habit of leaving the stream to moult after every instar. This laborious behaviour has not been observed in Australian toebiters, but much of their life history is still unknown.

Spongefly larvae, lacewing larvae

(Order: Neuroptera, Families: Sisyridae, Osmylidae and Neurorthidae)

This order includes some of the strangest aquatic insects. They are usually quite rare but very distinctive.

Distinguishing characteristics

Three distinct families of Neuroptera are aquatic. The sisyrids are small (<5 mm) pudgy animals with long outwardly curved mouthparts. Their bodies are covered with pale sclerites and erect setae and they have two rows of folded gills on the underside of their abdomen. They have segmented legs, but move very slowly. The osmylids are much bigger (20 mm), darkly sclerotised and with outwardly curving mouthparts. They lack gills, but are similarly covered in setae and sclerites. Their abdomens end in a robust pair of hooked pro-legs and sometimes the entire larvae can have a blue-purple iridescence. The neurorthids are slender animals, with inwardly curving mouthparts. Their sclerotised parts are usually a deep orange and they have a distinctively thin 'neck'. The adults of all three families are lacewings, with busily veined wings. They are active predators.

Sisyrids feed exclusively on freshwater sponges, which they probe with their slender mouthparts. The upper set of appendages on this animal are antennae.

Osmylids are odd-looking animals. Usually land based, they sometimes venture into water to hunt. Their water-repellent skin prevents them becoming victims of surface tension.

Possible misidentifications

The sisyrids and the osmylids are odd enough to be unmistakable. The neurorthids could be confused with beetle larvae, but they differ by having a distinctive neck.

Classification and distribution

The commonest member of the Sisyridae found in temperate Australia is *Sisyra*. The Osmylidae is a diverse group, including four terrestrial subfamilies as well as the semi-aquatic Kempyninae. This subfamily includes three genera, some of which are shared with New Zealand. The Neurorthidae is a small family with a single genus found in south-eastern Australia.

Most adult neuropterans have a similar appearance and are known collectively as lacewings. They are often attracted to lights where they prey on smaller, slower insects such as aphids.

Habitat and ecology

The sisyrids are true spongeflies, feeding on sponge tissues with their odd, tubular mouthparts. They are restricted to water where sponges occur: slow-moving or larger rivers and lakes. The osmylids are semi-aquatic and are thought to use their long mouthparts to probe for chironomid larvae in softer sediments. The neurorthids live in fast-flowing streams and are thought to be predators, but very little is known about their biology.

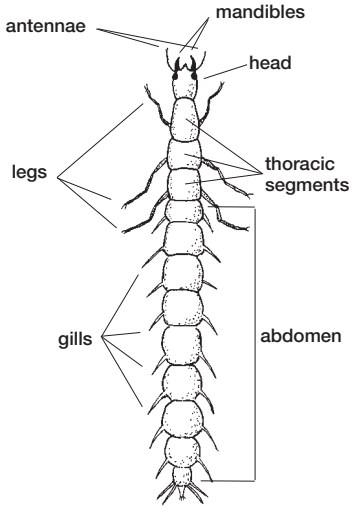
The neurorthids are one of the fastest macroinvertebrates and this makes them both efficient predators and difficult to photograph.

Natural history

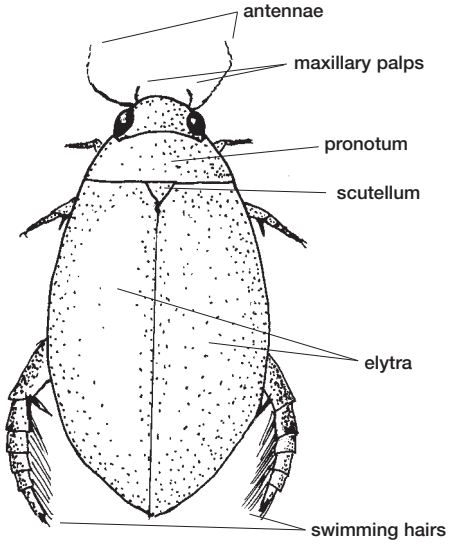
The larvae of all lacewings have their fore- and mid-guts separated and they do not join up until pupation. This leaves the animals effectively constipated until adulthood.

Beetles (Order: Coleoptera)

Beetles are the largest and one of the most diverse groups of animals on Earth with more than 300,000 known species. Many of them have successfully colonised freshwater habitats.



Generalised aquatic beetle larva



Generalised aquatic beetle adult

Distinguishing characteristics of adults

Aquatic beetles can look very similar to terrestrial beetles. They both possess elytra, the hardened (sclerotised) modified forewings that cover the hind wings and abdomen. However, most aquatic beetles can be separated from their terrestrial relatives by the presence of swimming hairs on their legs, and by their more streamlined body shapes. The diving beetles, for example, have adopted a droplet shape and paddle-like hind legs so that they can swim through the water more efficiently.

Some water scavenger beetles, like this *Helochares* sp., resemble terrestrial beetles.

Despite living in the water, many adult beetles have retained their ability to fly, and this allows them to disperse quickly to new habitats.

Distinguishing characteristics of larvae

Beetle larvae look very different from adults and can vary greatly in their appearance from family to family. Most larvae are elongated and have three pairs of walking legs and a sclerotised head capsule with mouthparts and antennae. The larvae lack wing pads and have well-developed legs.

Classification

The great diversity of aquatic beetles often makes them difficult to identify to family level. In this chapter we have included only those groups of beetles which are most likely to be found in aquatic samples. We have omitted groups which are relatively rare (e.g. Chrysomelidae, Microsporidae, Noteridae) and groups which are not strictly aquatic but wander in and out of the water (e.g. Carabidae and Staphylinidae).

Natural history

Coleoptera means sheath-winged and refers to the elytra. This protective cover gives beetles an advantage over other insects. Together with sclerotisation underneath the abdomen and thorax, it protects beetles from desiccation, predation and mechanical damage to their body. Equipped with this armour beetles can occupy many different habitats.

Most aquatic beetles live in water as both larvae and adults. However, some families such as Ptilodactylidae, Scirtidae and Psephenidae live in the water only as larvae, while most Hydraenidae are aquatic only during their adult stage.

The lifecycle of beetles includes four stages: egg, larva, pupa and adult. Pupation commonly occurs in soft mud and vegetation beside the water, but once adult beetles have emerged they can return to the water. Adults play an important role in dispersal, as many retain their ability to fly. Mating takes place in the water or near the water. Some water scavenger beetles (Hydrophilidae) use calling signals under water to find mates.

Beetle larvae have a variety of shapes and forms: the cockroach-like larva of Scirtidae (top), the flattened larva of Psephenidae (middle), and the long-legged larva of Dytiscidae (bottom).

Key to beetle larvae

1 legs absent or very short; unsclerotised grub-like body, often found inside submerged aquatic plants ..... **Curculionidae** (**aquatic weevils**, p. 97)
1 not with the above combination of features **2**

2(1) antennae longer than head and first thoracic segment combined ..... **Scirtidae** (p. 111)
2 antennae shorter than head and first thoracic segment combined. **3**

3(2) gills present on ventral surface of abdomen ..... **Hygrobiidae** (p. 108)
3 no gills on ventral surface of abdomen **4**

4(3) eight abdominal segments visible from above **5**
4 nine or ten abdominal segments visible from above **7**

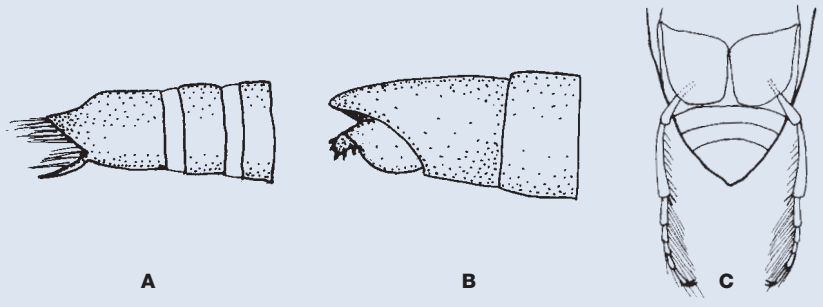
5(4) body disc-like with dorsal plates covering head and legs ..... **Psephenidae** (**water pennies**, p. 109)
5 body elongate, not disc-like; head and legs not covered by dorsal plates **6**

6(5) legs longer than thorax; mandibles sickle-shaped without teeth on inner margin ..... **Dytiscidae** (**diving beetles**, p. 98)
6 legs shorter than thorax; mandibles sickle-shaped, but with one or more teeth on inner margin ..... **Hydrophilidae** (**scavenger beetles**, p. 106)

7(4) body with nine abdominal segments visible from above, body slender, well-sclerotised, without any processes or gills **8**
7 body with ten abdominal segments visible from above; body with processes or gills **9**

8(7) abdominal segment 9 with a ventral flap (drawing A); usually small (<10 mm) ..... **Elmidae** (**riffle beetles**, p. 100)
8 abdominal segment 9 without a ventral flap (drawing B); usually larger than 10 mm with waterproof skin ..... **Ptilodactylidae** (p. 110)

9(7) ten pairs of feathery gills on sides of abdomen; last segment narrow, with 4 hooks; length up to about 20 mm. ..... **Gyrinidae** (**whirligig beetles**, p. 102)
9 no feathery gills; dorsal surface with rows of short or thread-like processes; last abdominal segment narrow with long tail; length up to 6mm ..... **Haliplidae** (**crawling water beetles**, p. 103)



Key to adult beetles

1 hind legs shorter than forelegs; mid and hind legs strongly paddle-shaped; found in schools on the surface of stagnant or slow-flowing waters ..... **Gyrinidae** (**whirligig beetles**, p. 102)

1 hind legs much longer than forelegs; behavioural characteristics not as above **2**

2(1) large coxal plates covering bases of hind legs and abdomen (drawing C) ..... **Haliplidae** (**crawling water beetles**, p. 103)

2 no large hind coxal plates; bases of hind limbs exposed (drawing D) **3**

3(2) head with distinct snout (drawing E) ..... **Curculionidae** (**aquatic weevils**, p. 97)

3 head without snout **4**

4(3) antennae club-shaped (drawing F) **5**

4 antennae slender, bead-like or thread-like (drawing G) **7**

5(4) antennae 9-segmented with 5-segmented club; abdomen with 6 or 7 ventral plates; body length less than 4mm; maxillary palps are longer than antennae or pronotum has laterally extending plates ..... **Hydraenidae** (p. 104)

5 antennae 7 to 9-segmented with 1-, 3- or 4-segmented club; abdomen with 5 ventral plates; body length between 2 and 40 mm; if maxillary palps longer than antennae then body length longer than 4 mm; no lateral plates on pronotum **6**

6(5) pronotum narrower than base of elytra, dorsal surface strongly sculptured ..... **Hydrochidae** (p. 106)

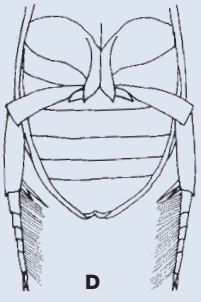
6 pronotum not narrower than the base of elytra, dorsal surface not strongly sculptured ..... **Hydrophilidae** (**scavenger beetles**, p. 106)

7(4) legs not adapted for swimming; adults crawl; occur in well-oxygenated mostly flowing waters; body size up to 5–6 mm ..... **Elmidae** (**riffle beetles**, p. 100)

7 hind legs adapted for swimming; body length variable **8**

8(7) eyes protruding; body stout and oval, 8–10 mm long; dorsal surface strongly arched ..... **Hygrobiidae** (p. 108)

8 eyes not protruding; size and body shape variable ..... **Dytiscidae** (**diving beetles**, p. 98)



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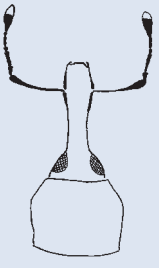

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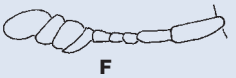

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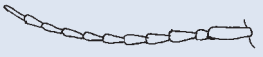


G

The body surface of some diving beetles is so smooth that males need suction discs on the ends of their front legs to hold a female during copulation. This is *Onychohydrus scutellaris*.

Aquatic adaptations

Beetles are one of the groups of invertebrates that entered the aquatic environment after living and evolving on dry land for millions of years. This evolutionary invasion of water meant that beetles had to adapt to a new and very different environment.

Breathing while under water is one of the main problems for animals adapted to life on land. Some groups of beetles still rely solely on air while others have evolved to use oxygen dissolved in the water. Hydrophilid beetles and several other groups have special hairs which trap an air bubble underneath their abdomen.

Dytiscid beetles store an air bubble under their elytra and return to the surface from time to time to replenish the air. This behaviour gives them their common name, 'diving beetles'. Adult Elmidae (riffle beetles) use a plastron—a physical lung, formed by specialised hairs trapping a very thin layer of air around the abdomen. As oxygen in the layer is used, its concentration decreases compared to the concentration of oxygen in the water. This causes the diffusion of new oxygen across the plastron. Because this system relies on high concentrations of oxygen in the water, plastron users are restricted to well-oxygenated waters, usually shallow, swift creeks with cold water.

The layer of air underneath the abdomen of the hydrophilid *Enochrus* sp. shines underwater.

A diving beetle with a bubble of air at the tip of the abdomen.

Aquatic weevils (Family: Curculionidae)

Distinguishing characteristics of adults

The head ends in a long snout. Antennae are attached to the snout, angled and have a club at the end. Body size is up to 9 mm.

Distinguishing characteristics of larvae

Larvae are legless with a soft unsclerotised body except for the head capsule. Mouthparts are directed downward.

Possible misidentifications

Both adults and larva are very distinct. The best distinguishing feature of the adult is the elongated head. Larvae can be confused with some fly larvae and with larvae of Chrysomelidae. A relatively large sclerotised head should help in separating the weevil larvae.

Classification and distribution

There are several genera of aquatic weevils. Many species are semi-aquatic. The genus *Bagous* is quite common and has been recorded in all states and territories. The native species *B. hydrillae* has been introduced to the USA to help with the biological control of an aquatic weed.

Habitat and ecology

Both adults and larvae live in stagnant or slow-moving waters. Adult beetles crawl among submerged water plants while larvae live inside air-filled stems of aquatic plants. There is very little known about the biology of Australian aquatic weevils. Both adults and larvae are herbivorous.

Natural history

Adults lay their eggs within stem tissues near leaf joints. The larvae hatch in three to four days and feed on the internal stem tissues. There are three larval instars each lasting several days. The third instar larvae exit and subsequently pupate in dry soil.

An adult *Bagous* sp. Is up to 9 mm long.

The head of a curculionid has a characteristic snout.

Larvae breathe air obtained from inside the plant stems while adults use a combination of plastron respiration and breathing atmospheric oxygen when oxygen saturation in the stagnant water becomes limiting.

Diving beetles (Family: Dytiscidae)

Distinguishing characteristics of adults

Adult diving beetles can be recognised by their streamlined shape and thin antennae. Both dorsal and ventral surfaces of the body are convex. Hind legs have paddle-like tarsi bearing a dense fringe of swimming hairs. Adult beetles range from 2 to 35 mm long.

Distinguishing characteristics of larvae

Larvae are elongate with long legs covered with swimming hairs. They have large sickle-like mandibles that are almost always deeply grooved or perforated. Some larvae have characteristic projections on their heads. A pair of large spiracles is located at the tip of the abdomen. Many dytiscid larvae have two tail filaments attached at the end of the abdomen.

Possible misidentifications

Adult dytiscids can be confused with other beetles having a streamlined body shape. Some hydrophilids have similar size and shape and their clubbed antennae, which serve as a distinguishing character, are often held under their head. Hydrophilids can be distinguished by their flatter ventral surface and more convex dorsal surface compared to most dytiscids. Adult dytiscids swim by moving their hind legs simultaneously similar to a breaststroke swimmer, but hydrophilids swim by moving their hind legs alternately. When coming to the surface to renew their air supply, adult dytiscids pierce the water surface with the tip of the abdomen; hydrophilids use their antennae.

The hind legs of a diving beetle are fringed with swimming hairs.

A 5 mm long *Megaporus* sp. moves swiftly through the water.

Some dytiscid larvae have characteristic projections on their heads.

An 8 mm long dytiscid larva showing its large, piercing mandibles.

Dytiscid larvae can resemble hydrophilid larvae but can be distinguished by having longer legs and serrated rather than smooth mandibles.

Classification and distribution

Diving beetles are one of the most diverse groups of aquatic beetles with 226 species in 42 genera recorded from Australia. Twenty-four genera are endemic. The family Dytiscidae is very common and occurs throughout the continent.

Three genera and at least 16 species live in underground water bodies in the desert region of Western Australia and central Australia. Many more species from this subterranean habitat are waiting to be described.

Habitat and ecology

Diving beetles inhabit a number of different freshwater habitats but are most likely to be found in ponds, lakes, billabongs, dams and short-lived seasonally flowing streams where the water is stagnant or slow running. Adults often fly from one habitat to another. They use light reflected from the water surface to detect a new habitat and sometimes confuse light reflected from glass or artificial light with water.

Both adult and larvae are voracious predators. They eat other aquatic invertebrates and will sometimes attack small fish and tadpoles. Adult beetles have chewing mouthparts while most larvae have their mouth opening closed. They use their hollow mandibles to inject digestive enzymes into their prey and then suck out the dissolved flesh.

A dytiscid larva feeding on a small midge larva.

Natural history

Adult beetles often deposit their eggs into aquatic plants by making cuts in the stem using their ovipositor. Larvae pupate out of water in damp soil and the adults return to the aquatic environment.

Both larvae and adults use atmospheric air and come to the surface to renew their oxygen supply. Adults store oxygen in a bubble underneath the elytra while larvae use a siphon located at the tip of the abdomen.

This 4 mm long *Necterostoma.* sp is resting.

Rhantus suturalis replenishes its air supply.

Riffle beetles (Family: Elmidae)

Distinguishing characteristics of adults

Adult riffle beetles are small and darkly coloured with relatively long legs in relation to their body. Body size ranges between 0.9 and 6 mm.

Distinguishing characteristics of larvae

Larvae are elongate and hard-bodied. Their body is semi-circular in cross-section with colours from yellow to dark brown. The last abdominal segment bears tufts of thread-like gills. These can be exposed to the water current or covered by a flap (operculum) located underneath the last segment. Mature larvae are 2–6 mm long.

Possible misidentifications

Elmid larvae can be confused with ptilodactylid larvae. These two families can be separated by the ventral flap, which is present in elmids at the tip of the abdomen in contrast to the pair of lobes possessed by ptilodactylids. Ptilodactylid larvae can be up to three times longer than elmid larvae and their body surface is shinier and smoother. It is also possible to confuse adult elmids with small Hydrophilidae and Hydrochidae. However, Hydrochidae and Hydrophilidae occur only in stagnant or slow-moving waters and while alive adults can be distinguished by an air bubble underneath their bodies.

An adult elmid *Kingolus* sp. is only 1.5 mm long.

Classification and distribution

Two subfamilies of Elmidae known in Australia are Elminae and Larinae. Elmid beetles collected in the water are most likely to belong to Elminae. Common in upland streams, the sub-family includes six genera: *Graphelmis* (one species in Qld, NT and NSW), *Austrolimnius* (53 described species throughout Australia), *Kingolus* (11 described species, endemic to Australia), *Notriolus* (16 described species, endemic to Australia), *Simsonia* (16 described species, endemic to Australia) and *Coxelmis* (3 described species, endemic to Australia).

Elmid larvae, such as *Notriolus* sp., often feed on submerged woody debris.

An elmid beetle (*Austrolimnius*) with a silver layer of air retained by plastron hairs.

Adults of *Notriolus*, around 4 mm long, often have four light spots on their backs.

Adult Larinae beetles live on land while their larvae live in the water. The sub-family includes four genera: *Hydora* (one species found in New South Wales), *Ovolara* (two species in Queensland and New South Wales), *Stetholus* (one species in Victoria and New South Wales) and *Potamophilinus* (one species in the Nortern Territory).

Habitat and ecology

Elmids are most likely to occur in well-oxygenated upland streams on submerged wood or on rocks in riffles (hence the name: riffle beetles). Both adults and larvae feed on decaying vegetation and algae. Elmid beetles sometimes bore grooves in submerged logs. These grooves are significant to the ecology of submerged wood as they increase roughness of the wood surface and therefore make it possible for other invertebrates to colonise this habitat.

Natural history

After hatching, larvae go through five to seven instars. Last instar larvae develop a series of spiracles on the sides of the body, which allow them to emerge from the water and survive in damp areas close to the stream before pupating.

In Australia, adult beetles return to water without taking flight, shortly after they emerge from the pupal stage. Both larvae and adults crawl on submerged substratum and are unable to actively swim.

Living in swift waters and being crawlers rather than swimmers, means that riffle beetles do not have the luxury of coming to the surface to renew their air supply. Instead, larvae breathe using gills while adults breathe by means of a plastron, a thin film of air held by many microscopic hairs. The plastron enables diffusion of dissolved oxygen from the water, which can then be used for respiration. However, the use of a plastron restricts Elmidae to flowing waters with high concentrations of oxygen.

Whirligig beetles (Family: Gyrinidae)

Distinguishing characteristics of adults

Adult whirligig beetles have a streamlined body shape, are glossy black, and have their eyes divided into upper and lower portions. Their antennae are very short, and their front legs are much longer than the hind legs, which are broad and paddle-like. Body size ranges from 4 to 18 mm.

Distinguishing characteristics of larvae

Larvae are elongate, with a pair of lateral feathery gills on abdominal segments 1 to 8 and two pairs of feathery gills on abdominal segment 9. The last abdominal segment has two pairs of hooks. Their mandibles are enlarged and sickle-like.

Possible misidentifications

Both the adult and the larva are very distinctive. Adults can be separated from the Dytiscidae and Hydrophilidae by having long front legs and short mid and hind legs. Larvae might be confused with larvae of *Berosus* sp. (Hydrophilidae) and some Megaloptera larvae which also have lateral gills at the side of the body. Gyrinid larvae have 10 pairs of feather gills which are much shorter than the length of the body compared to *Berosus* larva with seven pairs of tube-like gills, which often exceed the length of the body.

When threatened, whirligig beetles quickly dive below the water surface.

Classification and distribution

The family Gyrinidae contains four genera in Australia: *Aulonogyrus*, *Dineutus*, *Gyrinus* and *Macrogyrus*. Nineteen species have been described from all states and territories.

Habitat and ecology

Whirligig beetles live in both still and running water. Adults can often be seen cruising on the water surface in small circles—hence their name—and forming large swarms of several dozen individuals. Larvae inhabit the bottom of streams or ponds.

Adults feed on small organisms that fall on the water surface, or scavenge on dead invertebrates. Larvae are active predators.

Gyrinid larvae inhabit the bottom of streams or ponds.

Gyrinid larvae have feathery gills and two hooks on the last abdominal segment.

Natural history

Little is known about the lifecycle of Australian whirligigs. In North America, the beetles copulate on the water surface and the female lays her eggs on the stems of emergent vegetation a few centimetres below the surface of the water. After hatching larvae pass through 2–3 instars. They pupate on land either in holes dug into damp earth or cells constructed by the larvae above ground using small pellets of mud.

Whirligig beetles have several remarkable adaptations. The most noticeable is the separation of their eyes into upper and lower pairs. As they spend most of their time on the boundary between the air and the water they need to keep an eye on what is happening above and below. In case of danger they can quickly dive below the water surface.

To detect small ripples generated by fallen insects, adult beetles are equipped with what is called Johnston's organ—a sensitive organ located on their antennae.

Adult gyrinids can swim very fast on the water surface as they secrete a surfactant that reduces the surface tension of the water, and thus the friction between them and the water.

Adults breathe atmospheric oxygen while larvae use lateral gills to breathe under water. The last larval instar develops functional spiracles and is capable of breathing atmospheric air.

Crawling water beetles (Family: Haliplidae)

Distinguishing characteristics of adults

These are small convex oval beetles with thin antennae. Enlarged coxal plates cover the bases of their hind legs. The scutellum is absent. The elytra are covered in a series of punctures and commonly have dark stripes or blotches. Body size 2.5 to 3.6 mm.

Distinguishing characteristics of larvae

Larvae are long and narrow with two pointy processes on each abdominal segment and a long tail on the last abdominal segment.

Possible misidentifications

Adults can be mistaken for Hydrophilidae or Dytiscidae. The best distinguishing features are the large coxal plates covering the bases of the hind legs, the thin antennae, the convex body form and the absence of a scutellum.

Classification and distribution

The family Haliplidae is represented in Australia by a single genus *Haliplus* containing fifteen species. The family occurs throughout Australia.

Haliplids are convex beetles with a series of stripes on their back.

The bases of the hind legs of haliplids are covered by coxal plates.

Habitat and ecology

Haliplids are found among aquatic vegetation in ponds, lakes and stream backwaters. Adults feed on green algae. The larvae feed on other plant material.

Natural history

Little is known about the lifecycle of haliplids in Australia. In the northern hemisphere larvae pass through three instars before pupation on land. Although the legs of the adults are equipped with swimming hairs they are slow swimmers. When haliplids swim they use alternate leg movements but most often they crawl among vegetation. Larvae breathe oxygen dissolved in the water.

Haliplid larvae live among aquatic vegetation and have a distinctive tail.

Family: Hydraenidae

Distinguishing characteristics of adults

These are small beetles between 0.8 and 2.5 mm long. Adults of the genus *Hydraena* have small antennae concealed in grooves beneath the head and relatively long maxillary palps. Adults of the genera *Ochthebius* and *Tympanogaster* have normal size maxillary palps but possess characteristic lateral plates on their pronotum. Adults can often be seen crawling upside down just under the water surface with a reflecting bubble of air on the ventral side of their abdomen.

Distinguishing characteristics of larvae

Larvae are rarely found in aquatic samples and are likely to be marginal. The larvae of *Tympanogaster* live in the splash zones of waterfalls.

Possible misidentifications

Hydraenid adults can be mistaken for Hydrochidae and some Hydrophilidae. Long maxillary palps or lateral thoracic plates, along with their small size, help to separate them.

An adult *Hydraena* sp. has small antennae concealed in grooves beneath its head and relatively long maxillary palps, which can be mistaken for antennae.

Hydraena sp. can often be seen crawling upside down just under the water surface with a reflecting bubble of air on the ventral side of its abdomen.

Adults and a larva of the genus *Tympanogaster* living in the splash zone of a waterfall.

Classification and distribution

Eight genera and 57 species have been described in Australia. The most common genera in south-eastern Australia are *Hydraena* and *Ochthebius*. The family occurs throughout the continent.

Habitat and ecology

Hydraenids live in a wide variety of habitats including streams, waterfalls, ponds, ditches, marine rock pools and inland salt lakes. They are most likely to be found in stagnant waters among aquatic vegetation and at the water edge. Little is known about the habitat and ecology of the larvae and most are probably terrestrial or semiaquatic. However, larvae of *Tympanogaster* living in the splash zone use tiny spiracular tubes to breathe under water. Hydraenids feed on algae.

Natural history

Little is known about the lifecycle of hydraenids in Australia. In the northern hemisphere hydraenids lay eggs on wood and stones just beneath the waterline. Newly hatched larvae leave the water and live in the littoral zone.

Adults breathe under water using a plastron but are capable of renewing their oxygen supply with atmospheric air.

An adult *Ochthebius* sp. showing the lateral plates on its pronotum and its shiny body surface.

Water scavenger beetles (Families: Hydrophilidae and Hydrochidae)

These two families are close relatives and Hydrochidae is sometimes regarded as a group within Hydrophilidae.

Distinguishing characteristics of adults

Most adults are recognised by their 7- to 9-segmented antennae with a 3-segmented club. The hind legs of many but not all adults have swimming hairs. A scutellum is always present at the base of the elytra.

Distinguishing characteristics of larvae

Hydrophilid larvae are variable. They have large serrated mandibles and their abdomens usually have a wrinkled appearance, with or without filaments on the side. Hydrochid larvae have not been found in the water.

Possible misidentifications

Often the antennae are tucked beneath the head and the long maxillary palps may be mistaken for antennae. The hydrochids are close relatives of the hydrophilids and adults from the two families look very similar. Hydrochid adults can be recognised because their pronotum is narrower than their elytra, and their body is covered with strong indentations. Hydrophilid adults have a smooth bubble-like form. Hydrophilid adults and larvae can also be confused with diving beetles (see page 98).

This adult *Anacaena* sp. is only 2 mm long.

A hydrochid adult can be recognised by the pronotum being narrower than the elytra and by its body covered with strong indentations.

Classification and distribution

Nineteen genera of aquatic hydrophilids are recorded in Australia. The most common genera in south-eastern Australia are *Berosus*, *Helochares*, *Enochrus* and

Adult *Berosus* beetles use their maxillary palps as sensory organs while underwater. Their antennae fulfil the same function on dry land.

A large hydrophilid larva showing the well-sclerotised head and serrated mandibles.

Larval *Berosus* have long filaments along their sides.

A female *Helochares* carrying eggs under her abdomen.

Limnoxenus. The Hydrochidae includes a single genus *Hydrochus* which has a worldwide distribution with around 27 recognisable species found in Australia.

Habitat and ecology

Hydrophilids are most often found in stagnant and slow-moving waters. Their typical habitats are wetlands, ponds, dams, and streams with slow current and plenty of aquatic plants. Most hydrophilid larvae are predacious. Adults are largely herbivorous but may scavenge on dead insects and other small animals.

Adult hydrochids are found in a wide range of habitats, most often in stagnant or slowly flowing waters, at the banks of rivers, billabongs and ponds. They are herbivorous, feeding on detritus, parts of plants and periphyton.

Natural history

Adults of some genera (e.g. *Berosus*) make characteristic stridulations under water or when captured. Females of some genera carry their eggs underneath the abdomen.

Both adults and larvae breathe atmospheric air. Adults store an air bubble underneath the abdomen and between the elytra and abdomen which gives them sometimes a silvery appearance. Most hydrophilid larvae breathe through two large spiracles at the tip of the abdomen. Some hydrophilids (e.g. *Berosus*) have a breathing siphon and large serrated mandibles. They are poor swimmers and prefer to crawl on aquatic plants, pieces of wood etc. while they move around and search for their prey. Hydrochids can't swim and instead crawl around on water plants, submerged wood and other surfaces.

Screech beetles (Family: Hygrobiidae)

Distinguishing characteristics of adults

Hygrobiid adults are stout beetles around 10 mm long, with bulging eyes and without the smooth outline of diving beetles. They usually crawl but can swim using alternating leg movements.

Distinguishing characteristics of larvae

Larvae are well sclerotised and rounded, with feather-like abdominal gills and a long tube-like extension to the abdomen which, with two long filaments, results in a distinctive, three-pronged end to the abdomen.

Possible misidentifications

Adults and larvae can be confused with hydrophilids or dytiscids. Adult hygrobiids can be separated by their bulging eyes. Hygrobiid larvae are unusual in having feather-like gills underneath their abdomen. They also have three filaments at the tip of the abdomen while most dytiscid larvae have only two or none.

Classification and distribution

The family Hygrobiidae includes a single genus, *Hygrobia*. Two species occur in south-eastern Australia, one species in North Queensland and the Northern Territory and one in the south-west. Two other species are found in Europe, North Africa and China.

A larva of *Hygrobia* sp. with its characteristic three-pronged tip of the abdomen.

Habitat and ecology

Screech beetles occur in stagnant muddy waters of dams, ponds and wetlands. They are predators on other invertebrates.

Natural history

Unlike dytscids and hydrophilids, hygrobiid larvae possess gills at the base of their legs and underneath the first three segments of the abdomen. These possibly compensate for the fact that dissolved oxygen can't really disperse through their skin.

Adult screech beetles look a bit like goggle-eyed diving beetles.

Water pennies (Family: Psephenidae)

Distinguishing characteristics of adults

Adults are terrestrial. They are broad, somewhat flattened and dark coloured. They have a distinctively serrated join between their pronotum and elytra.

Distinguishing characteristics of larvae

Larvae are distinctly flattened and disc-like, oval or sometimes round. Side extensions of every segment form a shield, which completely covers the head and legs of the animal from above. The body shape of the larvae resembles that of trilobites.

Possible misidentifications

It is almost impossible to confuse psephenid larvae with any other family.

Classification and distribution

A single genus *Sclerocyphon* with 13 described and 5 undescribed species represents this family in Australia. The family is widespread throughout the world.

Habitat and ecology

Larvae are commonly found in strongly flowing or turbulent sections of a stream, but can survive in stagnant water if it is well oxygenated. Most often they are attached to rocks or large logs. Larvae are strictly benthic and feed on periphyton and other plant material covering the stream bed.

Adult water pennies are broad, flattened and dark coloured.

Natural history

Larvae spend from 12 to 22 months in the water. The adults live around two months. The mature larva leaves the water to pupate in the litter and soil of the river bank. When the larva is out of the water it can breathe atmospheric oxygen using a pair of spiracles covered by brushes on the last abdominal segment. Adults live in vegetation near the stream edge. Females crawl down the sides of emergent rocks to lay their eggs under the water. Unlike many other beetle larvae, they breathe oxygen dissolved in the water. They use their retractable gills at the tip of their abdomen, which they wave around to increase oxygen absorption. The larval body shape is ideal for clinging to rocks and minimising water resistance.

The body shape of a psephenid larva resembles that of a trilobite.

One needs to look from underneath to see a psephenid larva's legs and head.

Family: Ptilodactylidae

Distinguishing characteristics of adults

Adult ptilodactylids are terrestrial. They are elongated, hairy beetles with striated elytra and antennae longer than half the body length.

Distinguishing characteristics of larvae

Larvae are elongated and sub-cylindrical in cross-section. They are hard-bodied and pale brown in colour. The most distinguishing feature of the larva is a pair of lobes with hooks at the posterior tip of the abdomen.

Possible misidentifications

See Elmidae.

Classification and Distribution

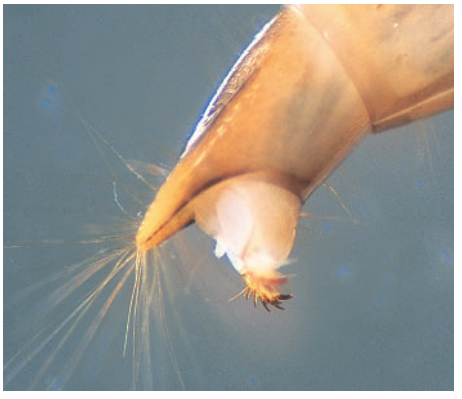
Australian ptilodactylid beetles, both terrestrial and aquatic, include 15 described species. All aquatic species belong to the genus *Byrrocryptus* which occurs along the east coast of mainland Australia.

Habitat and ecology

Larvae live in running water and feed on decaying plant material including wood.

Natural history

Very little is known about the lifecycle of the Australian Ptilodactylidae.



A larva of *Byrrocryptus* sp. The tip of its abdomen has a pair of lobes with hooks.

Marsh beetles (Family: Scirtidae)

Distinguishing characteristics of adults

Adult marsh beetles are terrestrial. They have a round, flattened body and are up to 11 mm long.

Distinguishing characteristics of larvae

Larvae are elongate, flattened, and range in size from 5 to15 mm long. The segments are sclerotised but the larvae look soft and flexible. Their most distinguishing feature is their multi-segmented antennae, which are longer than the combined length of the head and the first thoracic segment. Their overall appearance resembles that of a juvenile cockroach.

A marsh beetle larva with its characteristically long antennae.

Possible misidentifications

Marsh beetle larvae are easily distinguishable by their antennae, and are not likely to be confused with any other aquatic beetle larvae.

Classification and distribution

Six genera and more than 50 species are known from Australia. The more common genera are *Scirtes*, *Cyphon* and *Prionocyphon*.

Habitat and ecology

As their name implies, most marsh beetle larvae live in marshes, wetlands, ponds, dams, and streams with slow current and plenty of aquatic plants. Sometimes they are found along the edges of faster flowing streams. They feed on detritus, filtering it from the surface of leaves and stones using their complex comb-like mouthparts. They breathe atmospheric air through the tip of the abdomen and therefore have to come to the surface for air from time to time. Often they are seen crawling upside down on the underside of the water surface.

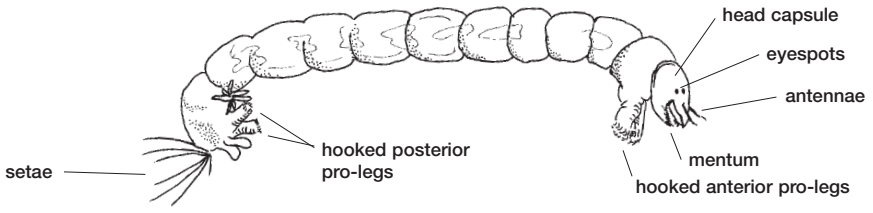
Natural history

Little is known about the life history of Australian marsh beetles. They produce one generation a year in temperate Australia. Larvae pupate among dead leaves or in mud chambers or cells on land.

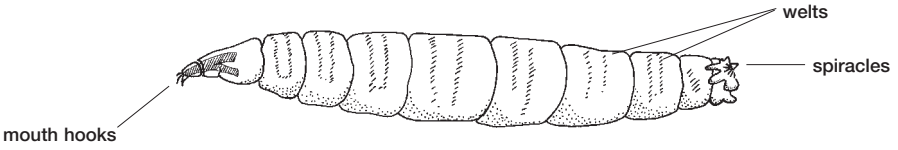
Flies, true flies (Order: Diptera)

The dipterans are a very diverse group of insects that occur in most, if not all of the inland waters of temperate Australia. They can be found in a range of environmental conditions, thriving in septic tanks and wilderness areas alike.

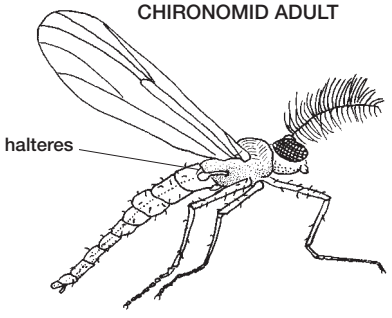
CHIRONOMID LARVA



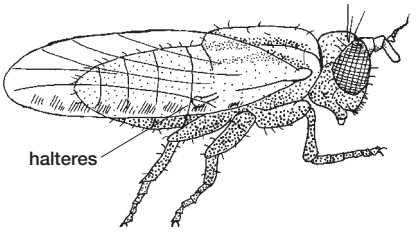
SCIOMYZID LARVA



CHIRONOMID ADULT



SCIOMYZID ADULT



The larvae of midges (Chironomidae) and marsh flies (Sciomyzidae) provide the two extremes of body structure between which most dipterans will fit.

Fly spotting

While it is almost impossible to identify most adult flies while they are alive, some of the commoner families can be recognised by the following characters:

crane flies (Tipulidae): very long legs; slow cumbersome flight, long abdomens

black flies (Simuliidae): small, black, with rounded wings and fat little bodies

non-biting midges (Chironomidae): small delicate flies; males have fluffy antennae; unlike mosquitoes they keep their front legs (rather than their middle ones) in the air when resting

mosquitoes (Culicidae): slender bodies, fine wings and long piercing mouthparts; second pair of legs raised when resting

hover flies (Syrphidae): often orange/cream and black (wasp mimics) with hovering flight

horse flies (Tabanidae): large eyes (almost touching); robust bodies; piercing mouthparts

marsh flies (Sciomyzidae): some of the commoner swamp genera have spotty wings and a streamlined body

Characteristics of an adult fly

Adult flies have large compound eyes and a single pair of wings. Most of the other insects dealt with in this book have two pairs of wings: one on the mesothorax and the other on the metathorax. Flies have reduced their second set of wings to a pair of small knobs (halteres) and these aid in balance during flight. Diptera translates from the Greek as 'two-winged' (*di* = two, *ptera* = wings).

A diverse range of adult flies can be found near fresh water. Some of these skate on the water surface, where they scavenge or prey on dead or dying insects—a similar life to the water striders (Hemiptera). Others can be found in swarms above water, or clinging to vegetation and rocks nearby. The adults are usually agile fliers, capable of travelling long distances and this helps make many of these insects widespread if not common.

Clytocosmus (Tipulidae) is one of the larger, more brightly coloured dipterans.

Adult male chironomids have highly sensitive antennae that they use when finding females.

Key to the common families of aquatic dipteran larvae

1 stocky larvae with 6 wide body segments and a row of suction cups on their underside ..... **bleffs or net-winged midges** (**Blephariceridae**, p. 118)
1 not as above **2**

2(1) elongate pear-shaped larvae with a hook-lined suction cup at one end, and feathery mouthparts at the other ..... **black flies** (**Simuliidae**, p. 129)
2 larvae not as above **3**

3(2) larvae with most segments sclerotised: either totally or only on the dorsal surface ..... **moth flies and soldier flies** (**Psychodidae** and **Stratiomyidae**, p. 128)
3 larvae not as above **4**

4(3) larvae with many stiff erect hairs, final segments heavily sclerotised **5**
4 larvae without many stiff erect hairs and without a heavily sclerotised final segment **6**

5(4) larvae transparent or bent like a 'U' and final segment with three lobes, the central one with tufts of hair ..... **'U' bent larvae or meniscus midges and phantom midges** (**Dixidae and Chaoboridae**, p. 123)
5 larvae not as above ..... **mosquitoes, wrigglers** (**Culicidae**, p. 122)

6(4) larvae with a sclerotised head capsule **7**
6 larvae without a sclerotised head capsule, head retractable into thorax **12**

7 larvae without any pro-legs **8**
7(6) larvae with pro-legs **9**

8(7) hind end of larvae with hairs, but without fleshy projections, head not retractable into thorax ..... **pogs, biting midges or sand flies** (**Ceratopogonidae**, p. 119)
8 hind end of larvae with fleshy projections and sometimes hairs, head retractable into thorax ..... **some tipulids: dollies, march flies and crane flies** (**Dolichopodidae**, **Tabanidae and Tipulidae**, p. 124)

9(7) larvae with paired fore and hind pro-legs **10**
9 larvae either without front pro-legs, or with single pro-legs **11**

10(9) most body segments with spines or processes ..... **Forcipomyiinae: pogs, biting midges or sand flies** (**Ceratopogonidae**, p. 119)
10 most body segments without spines or processes ..... **non-biting midges, 'mids** (**Chironomidae**, p. 120)

11(9) larvae either with a single front pro-leg, or with long fleshy projections on the final segments **14**
11 larvae without front pro-legs, or fleshy projections ..... **Dasyheleinae: pogs, biting midges or sand flies** (**Ceratopogonidae**, p. 119)

12(6) larvae with 7-8 pairs of well developed hooked pro-legs ..... **Athericidae and Empididae** (p. 116)
12 larvae without 7-8 pairs of hooked pro-legs **13**

13(12) larvae long and parallel-sided with rounded ends, often worm-like in appearance ..... **dollies, march flies and crane flies** (**Dolichopodidae, Tabanidae and Tipulidae**, p. 124)
13 larvae taper towards the front, maggot-like in appearance ..... **ephydrids, muscids, marsh flies and rat-tailed maggots** (**Ephydridae, Muscidae, Sciomyzidae and Syrphidae**, p. 126)

Key to the common families of aquatic dipteran larvae (contd.)

14(11) larvae with long fleshy projections on the final segments ..... **Tanyderidae** (p. 130)

14 larvae with a single front pro-leg; without long fleshy projections on the final segments ..... **Thaumaleidae** (p. 130)

Characteristics of a larval fly

Fly larvae vary considerably in their body structure. Chironomids and sciomyzids provide the two extremes of body structure between which most dipteran larvae will fit. Chironomid larvae are elongate, with distinct pro-legs and a head capsule, while the sciomyzid larvae are maggot-like. Some dipteran larvae have well-developed head capsules with eyespots, while others are maggot-like with soft 'heads' and only their internal mouthparts hardened. Many have pro-legs and these can be quite large (as in the midges/chironomids) ending in lots of hooks, or they can be broad stumpy structures that are more like raised welts (as in the empidids). None of them have jointed legs, none of them have wing buds and very few have sclerotised thoracic segments.

Larval tipulids are soft-bodied maggots with a pair of posterior spiracles surrounded by fleshy projections. Most are not as spectacular as the regal maggot *Clytocosmus*.

Classification

The 20 families with aquatic larvae that are dealt with in this book include some of the greatest diversity within the Diptera. The Chironomidae and the Culicidae are each represented by more than 200 species Australia-wide and the Tipulidae by around 700 species (though many of these are terrestrial). Other families are less diverse, but the taxonomy of the aquatic families is still far from complete and many new species are likely to be discovered as research into their ecology and biology progresses.

Larval tanypods (left) are predators, while simuliids (right) are filter feeders. Both have simple bodies with head capsules and eyespots.

The key on these pages is a rough guide to family, or groups of families where the animals are more difficult to distinguish. Care should be taken with the less common larvae such as the Tanyderidae, as they closely resemble other more common animals. Fleshy dipteran larvae can often retract parts of their bodies such as heads, spiracles and pro-legs and this can make some individuals very difficult to identify.

Maggots and the fast life

Many aquatic fly larvae have short lives, which allows them to grow in temporary water in ponds and puddles. They also have simple bodies so they can make the most of food when it is available. Their simple larval body works a bit like an elastic-sided garbage bag and can stretch to accommodate a large meal better than a complicated nymph-like body can. These opportunistic characteristics allow some fly species to complete five or six lifecycles in a year. The shortest recorded larval stage is under two weeks, with adults maturing almost immediately after emergence.

Adult flies can lay hundreds of eggs and rarely live for longer than a month (regardless of the length of the larval life). This makes the shortest dipteran lifecycle, from egg to egg-laying, a little over two weeks. Some of the fastest living Diptera are from the family Chironomidae.

Environmental significance

The extreme variability of dipterans extends to their tolerance of pollution. Some of the hardiest animals, such as the rat-tailed maggots (Syrphidae) actually prefer organically polluted sites and thrive in sewage and carrion. At the other extreme, the tanyderids are restricted to cold mountain streams with a healthy supply of wood and leaf litter and are intolerant of most pollutants.

Diverse and well-studied families such as the non-biting midges (Chironomidae) can provide much information about their surrounding environment. Different species are often indicative of different environmental conditions such as water chemistry. Sometimes these changes also indicate environmental impacts. In extreme cases of pollution, the deformities of the more tolerant species can be studied to assess environmental impacts.

Families: Athericidae and Empididae

Distinguishing characteristics

Athericid larvae have fleshy bodies, no sclerotised segments, paired pro-legs on abdominal segments 1–7 and a single leg on segment 8. Empidid larvae have paired pro-legs on abdominal segments 1–7 and either no pro-legs or two pro-legs on segment 8. Athericids have distinct fleshy projections along the sides of their bodies, but empidids don't. Both feed using a pair of sclerotised hook-like mouthparts that retract into the front of their body. Athericid larvae grow to around 10 mm, while aquatic empidid larvae are usually smaller (3–5 mm), but can reach the same size. Adult athericids are stocky little flies a bit like black flies (Simuliidae), but they aren't commonly encountered. Empidid adults are more common and are sometimes called 'dance flies' because they spend their time moving rapidly over the water surface looking for prey. They have a distinctive 'beak' for piercing prey.

Larval empidids, as with all maggot-like fly larvae, can alter their length and are usually more truncate than this.

Possible misidentifications

Some ephydrids (page 126) may resemble athericids, but ephydrid larvae never have fleshy projections along their sides.

Classification and distribution

The Athericidae was previously considered part of the Rhagionidae. One genus of athericid (*Dasyomma*) is known from southern Australia and also occurs in South America. The 11 Australian species within this genus can only be identified as adults. The Empididae is a large family; many of its representatives are terrestrial.

Habitat and ecology

Larval athericids and empidids are predators, feeding on a range of smaller invertebrates. Their hook-covered pro-legs give them a solid purchase in faster-flowing waters and their flexible bodies allow them to travel easily through the gravel in riverbeds. Some adult athericids are thought to feed on blood but don't seem to bother humans.

Adult empidids use their piercing mouthparts to prey on other insects trapped on the water surface.

Natural history

In the northern hemisphere, larval athericids leave the water to pupate and adults are thought to lay their eggs on foliage that overhangs a stream. This allows the newly hatched larvae to drop straight into the water. It is likely that Australian athericids behave similarly.

Larval athericids have a distinctive set of lateral projections, and a pair of longer terminal ones. They move by stretching and contracting their bodies.

Bleffs or net-winged midges (Family: Blephariceridae)

Distinguishing characteristics

Bleff larvae have their bodies divided into six broad lobes, each with a suction cup on the ventral side. The head is set into the front segment and adorned with short antennae. Larvae move sideways when they are disturbed. This motion involves detaching the front suckers, flexing sideways and re-attaching them. This movement is repeated with the hind suckers and propels the animal swiftly but comically sideways.
In fast-flowing water, larvae progress slowly by detaching individual suckers and moving them forward. Larvae can grow to 13 mm. Adults are relatively slender and easily distinguished by the creased look of their wings and the fact that they generally hang from their front two legs near water.

Classification and distribution

Four genera and around 27 species of blepharicerid are found in south-eastern Australia. *Edwardsina* is the commonest genus (and the only one found in Tasmania), whereas three other genera (*Apistomyia*, *Austrocuripira* and *Parapistomyia*) are also found in New South Wales, Victoria and the Australian Capital Territory. The northern genera are thought to be strongly linked to fauna in the tropics, while *Edwardsina* seems to be a Gondwanan relic.

Bleffs have an instantly recognisable body shape.

Habitat and ecology

Bleffs graze the fine layer of periphyton (mainly algae) on the surface of rocks in the stream. Their suction-cup-covered undersides allow them to cling to rocks in very fast-flowing water.

Natural history

Bleffs are good indicators of a number of different human impacts. They prefer rocks in fast-flowing water, so they are sensitive to unseasonal changes in flow conditions brought about by dams and irrigation. They also seem to avoid the larger algae that tend to accumulate in nutrient-rich waters. This combination of characters restricts them to fairly pristine, fast-flowing waters.

The underside of a bleff has a row of suction cups which allow it to stick to rocks in places where no other invertebrates can venture.

Adult bleffs hang by their front legs from the undersides of branches and rocks along the sides of the stream.

Pogs, biting midges or sand flies (Family: Ceratopogonidae)

Distinguishing characteristics

Pogs are a diverse group, with four very different body shapes, belonging to the four different subfamilies. The commonest form (Ceratopogoninae) is very long and thin and moves with a fast, stiff, snake-like motion. They have a bullet-shaped head and a rosette of hairs on their final segment. Most pogs are under 20 mm long. The adults are slightly stockier than chironomids and have long antennae.

Possible misidentifications

The Dasyheleinae can be easily confused with chironomids or thaumaleids, though they differ by lacking a front pair of pro-legs. The Forcipomyiinae can also resemble the Thaumaleidae. Forcipomyiinae have a front pair of pro-legs, but they are usually covered with spines or processes and lack the small sclerotised breathing tube that thaumeleids have on their first thoracic segment.

Classification and distribution

Four subfamilies of Ceratopogonidae occur in Australia: Ceratopogoninae, Dasyheleinae, Forcipomyiinae and Leptoconopinae. Although there are more than 100 species in south-eastern Australia, all four subfamilies are more diversely represented in northern Australia. Pogs occur worldwide.

Pogs have thin, fast-moving bodies with a conical head capsule at one end and a rosette of hairs at the other.

Habitat and ecology

Most members of the Leptoconopinae burrow in the sandy edges of rivers and estuaries. These are the unloved 'sand flies'. The Ceratopogoninae has members that occur commonly in streams, though usually in slower flowing sections or in the mud at the edges. The Dasyheleinae and Forcipomyiinae are much less common and are thought to occur in disconnected aquatic and semi-terrestrial habitats. Both of these groups tend to occur in stream samples after heavy rains, suggesting they are washed in from the puddles and water-filled tree hollows that they normally inhabit.

The ceratopogonid subfamily Forcipomyiinae contains some peculiar animals. Most have spines, or projections along their sides.

Pogs from the subfamily Dasyheleinae superficially resemble chironomids, but they lack front pro-legs.

Non-biting midges, 'mids (Family: Chironomidae)

Distinguishing characteristics

Chironomid larvae are long, with fleshy bodies and sclerotised head capsules. They usually have a pair of fleshy pro-legs on the first segment after the head and another pair on the final segment. Both are armed with small hooks. Chironomids move in open water by rapidly coiling and uncoiling their bodies. This gives them a hectic thrashing appearance. They move more calmly over rocks and plants, using an inchworm-like gait. Most chironomids are less than 10 mm long.

Many of the Chironominae are red, but the commonest genus in urban and rural sites is *Chironomus*.

Possible misidentifications

The Thaumaleidae and the Dasyheleinae (Ceratopogonidae) can both be mistaken for chironomids. The reverse is also possible. Both the Thaumaleidae and the Dasyheleinae are comparatively rare, however, and restricted to odd habitats. Two genera of chironomid (*Harrisius* and *Stenochironomus*) are superficially similar to tanyderids. Tanyderids differ by having more long fleshy processes attached to both the last and second last segments. The two chironomids have them on the last segment only.

The three most common subfamilies of chironomids: Tanypodinae (top, with large heads), Chironominae (bottom right, with double eye spots) and Orthocladiinae (bottom left).

Classification and distribution

The freshwater chironomids of temperate Australia can be split into six subfamilies. The Chironominae, Tanypodinae and Orthocladiinae are common and diverse, while the Diamesinae, Aphroteniinae and Podonominae are represented by two or three genera each. The three common subfamilies are found in most rivers and lakes, while the remaining three tend to occur at higher altitudes, or in colder waters. This possibly explains why the latter are more common in Tasmania than on the mainland.

The less common subfamilies of chironomids: Diamesinae (left with the dark collar), Aphroteniinae (middle) and Podonominae (right).

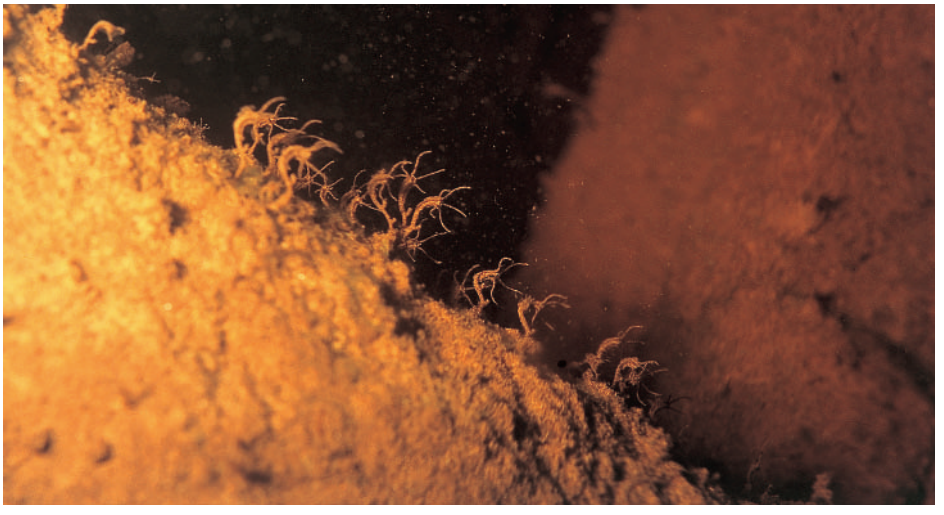
Habitat and ecology

Some members of the subfamily Chironominae are simple detritivores feeding on a mixture of algae and bacteria in soft sediments. This subfamily also includes filter feeders that build tubes adorned with a simple radial net, as well as a number of wood-boring species. Most of the Orthocladiinae are algal grazers, but some are predators or parasites and there are a few wood-boring species. All of the Tanypodinae are thought to be predators, though some may feed on algae and bacteria in their early larval stages. Most Aphroteniinae live and feed amongst fine organic matter in cold upland streams, but there are some recorded from sea level lakes in southern Western Australia. The Diamesinae and Podonominae feed on algae and bacteria, usually scraping it from the surface of rocks and wood. Diamesinae are typically found in thin-film waterfalls.

A mating pair of chironomids. The male is the one with the elaborate antennae.

Natural history

Some of the Chironominae have distinctive characteristics that allow them to be identified to genus quite easily. Bloodworms (*Chironomus*) are typical of organically polluted waters. They breathe dissolved oxygen using a very efficient blood pigment, which is similar to our own and gives them their distinctive red colouring. *Rheotanytarsus* builds a tube fringed with a net in flowing waters, while *Stempellina* and *Zavreliella* construct portable, sand-covered cases a bit like those used by caddis flies.



Rheotanytarsus larvae build nets around their tubes to catch food from the water as it flows past. The net is hung between the five struts that stick out from the edge of the tube.

Mosquitoes, wrigglers (Family: Culicidae)

Distinguishing characteristics

Larval mosquitoes have elongate, bristle-covered bodies. The first three segments behind the head are slightly wider than the abdomen. The abdomen ends in a sclerotised set of segments including a siphon (except in the Anophelinae) and a sclerotised and hair-covered last segment. Their heads are quite large and the mouth-parts usually involve a set of brushes that are used for sweeping microalgae into the mouth. Adults have distinctively long mouthparts, with which the females of some species will extract blood from mammals, but which most individuals use for drinking water and nectar.

Possible misidentifications

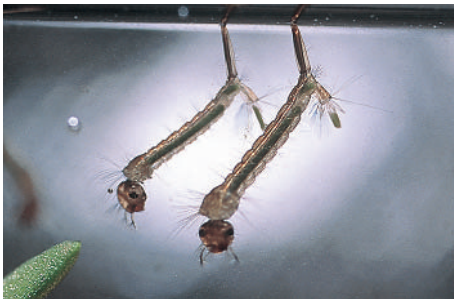
Dixid and chaoborid larvae are similar looking, but the first three thoracic segments aren't widened in the dixids and the chaoborids are fairly rare and quite transparent. Chaoborids have air sacs within their thorax and abdomen enabling them to float horizontally, while most mosquito larvae float with their heads hanging down. Mosquito larvae from the subfamily Anophelinae float horizontally but are well pigmented.

Classification and distribution

Two widespread subfamilies of mosquito are found in temperate Australia. The Culicinae are represented by around six genera and 70 species. The Anophelinae is less diverse with a single genus and fewer than 10 species. Species from these groups occur worldwide and the temperate Australian fauna has links with species in New Zealand, South America and Asia.

Habitat and ecology

Most mosquito larvae feed on microalgae, which they filter from the water with their hair-covered mouthparts. These feathery appendages create a current that pulls in food. Some mosquito larvae are predators and in many cases prey upon smaller mosquito larvae. All mosquito larvae are restricted to stagnant or slow-flowing water.



A pair of mosquito larvae hang from the surface, leisurely filtering the water with their brush-covered mouthparts.

Adult male mosquitoes do not take blood from mammals, but their needle-like mouthparts are just as useful for feeding on fruit and nectar.

Natural history

Mosquito larvae must return to the surface every now and then to replenish their air supply. Often they will float with their snorkel-like siphons puncturing the water surface and providing them with a constant supply of fresh oxygen. When they pupate, mosquito larvae swap from a breathing siphon attached to their abdomen, to a pair of breathing horns attached to their first thoracic segment. This swap changes the orientation of the animal in the water from

upside down, with the mouthparts dangling down in the water for feeding, to upright, with the back of the pupa towards the water surface. This allows the adult to break through the pupal skin and struggle through the water surface as it emerges. Mosquitoes are one of the few animals where both their common and taxonomic names are Latin. *Muscito* means small fly, *musca* being Latin for fly.

'U' bent larvae or meniscus midges and phantom midges (Families: Dixidae and Chaoboridae)

Distinguishing characteristics

Dixid larvae are long, thin surface-dwelling animals. Their bodies are covered with stiff hairs and these help them stay on the water surface while their heads are submerged. Their final segments are impressively ornamented. When dixids move, they flex their bodies into a distinct 'U' shape, and this propels them along the water surface or over wet mud/rock equally well. Chaoborids float mid-depth in still water, where they are predators of small invertebrates such as microcrustaceans. They have transparent bodies, with the first segment after the head enlarged to contain two flotation sacs. Their antennae are modified for shoveling small prey into their mouths.

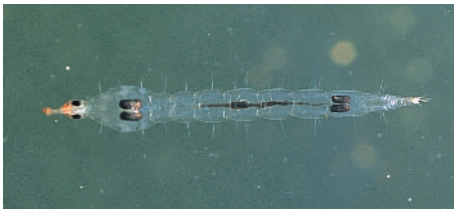
Dixids, like mosquito larvae, filter the water for algae. The plates and hairs on the final segment keep water from covering the spiracles.

Possible misidentifications

See Culicidae (page 122).

Classification and distribution

Two genera of dixid occur in south-eastern Australia: *Dixella* and *Nothodixa*, with six species between them. Four genera and at least six species of chaoborid are known from south-eastern Australia, but none of these is common.



Phantom midges (Family: Chaoboridae) are almost totally invisible to their prey. A pair of air sacs keep them floating horizontally.

Ecology and natural history

The dixids feed on planktonic algae, which they filter from just beneath the water surface with brush-like mouthparts. They occur in still waters such as small lakes, farm dams and on the edges of backwaters and pools. Larvae seem to be more comfortable holding onto vegetation or the mud of the bank, even though they are capable of resurfacing if they sink and sometimes will dive under the water if threatened. Chaoborids are mainly planktonic predators in lakes or smaller still waters, such as dams or even tree hollows.

Dollies, march flies and crane flies (Families: Dolichopodidae, Tabanidae and Tipulidae)

Distinguishing characteristics

The larvae of all three families are elongate and parallel sided, with heads that can be retracted into their first body segments. The Tipulidae and Dolichopodidae both have fleshy projections on their hind ends and some tipulids have these covered with hairs. Dolichopodids often have shorter projections that are lobed and curved in when viewed from the side. The hind ends of the tabanids are comparatively simple, as the spiracles are enclosed. All three families can have welts on their segments and sometimes these can include small hooks to help the larvae move. All three groups are variable in size, but some tipulid/tabanid larva can be longer than 30 mm. Adult tipulids are long-legged and sometimes called 'daddy long-legs'. Adult dolichopodids are usually metallic green and are water skimmers, while tabanids are march or horse flies and are known for their size and their painful bite.

Possible misidentifications

Some members of the Tabanidae aren't quite parallel sided, so it might be necessary to look more closely at the spiracles, which should be enclosed beneath a vertical slit at the hind end of the animal.

Dolichopodid larvae have a distinctive hind end, which allows them to be distinguished from the otherwise similar tipulids. The adults are metallic green, and have impressive raptorial tarsal claws.

Tabanid larvae are predators that can move through the stream bed to search for prey. Adults use their piercing mouthparts to extract blood from mammals.

Adult tipulids are sometimes referred to as crane flies, or daddy long-legs for obvious reasons.

Tipulid larvae can be quite variable. The animal on the left has a partial head capsule that can be retracted into its body, while the one on the right only has hardened mouthparts.

Classification and distribution

All three families are very diverse and widely distributed. The Tipulidae are probably the most diverse, with around 700 species Australia-wide.

Habitat and ecology

The larvae from all three families in this group are usually predatory. They are common inhabitants of fine sediments in slow-flowing water, but they do also turn up in faster-flowing areas, and marginal or terrestrial environments.

Ephydrids, muscids, marsh flies and rat-tailed maggots (Families: Ephydridae, Muscidae, Sciomyzidae and Syrphidae)

Distinguishing characteristics

The larvae of these families are less elongate than the previous group. Their bodies narrow gradually towards the front and their heads can be retracted into their first body segments. Syrphids can easily be distinguished by their long, tail-like siphon.

Possible misidentifications

All the maggot-like larvae are difficult to identify; you will make mistakes (but don't give up!). Some of the muscids and ephydrids have pro-legs, but they differ from the athericids by not having lateral projections. Empidids can be separated because they lack spiracles; members of these four families usually have well-developed spiracles.

Classification and distribution

All of the families within this group are fairly diverse and widespread. They also include species with terrestrial larvae. The family Muscidae, for example, includes a number of commonly encountered houseflies.

Habitat and ecology

Ephydrids and syrphids are thought to graze on microalgae. Both are typical of still waters and often occur in highly polluted or low oxygen environments such as stagnant, nutrient-rich puddles. Sciomyzids are predators on a range of molluscs in slow-moving or still waters. They are particularly abundant in wetlands, or in dams where their gastropod prey are present. Muscids are very diverse and occur in slow and fast-

The ephydrids are a common component of slow moving, stagnant and polluted water communities.

Sciomyzid larvae prey on small snails in dams and wetlands.

Adult sciomyzids have distinctively spotty wings, and are a common sight around wetlands.

Adult syrphids are a common sight in most gardens, as there are a number of terrestrial members in this family.

flowing water, where they are usually predators of other fly larvae and worms.

Natural history

Some North American ephydrids are famous for their ability to survive in pools of tar. So far this has not been recorded for Australian species.

Sciomyzids are known as marsh flies, or snail-killer maggots—a name that comes from their use as a biological control of pond snails, especially those that are thought to be a vector of sheep liver flukes. Sciomyzid larvae can voluntarily inflate their bodies and sometimes use this to drag snails from the pond bottom to the surface.

The ancient Greeks are said to have mistaken hover flies (Syrphidae) for bees and this led to a rather unsavoury ritual that they believed necessary to re-stock their hives. Syrphid larvae thrive in puddles of rotting carrion, so the ancients would bludgeon some livestock to death, then seal them into the equivalent of a small shed.

Syrphidae: the rat-tailed maggot (bottom) turns into a bee-like hover fly (top). The larva has a snorkel-like appendage which it uses to breathe.

The animals would rot and the syrphid larvae or rat-tailed maggots would thrive in the putrid puddles. Later, when the sheds were opened, a swarm of 'bees' would burst free. Syrphid larvae can survive in putrid water that lacks oxygen because they have an extendable snorkel that can stretch to the surface, even if it is several body lengths away.

Moth flies and soldier flies (Families: Psychodidae and Stratiomyidae)

Distinguishing characteristics

The larvae of moth flies and soldier flies differ from most other fly larvae by having hardened plates on their bodies. These cover the entire body of soldier fly larvae but are only transverse bands across the dorsal surface of moth fly larvae. Both families have a spiracle on their hind end that is surrounded by hydrophobic hairs and these often puncture the water surface in shallow water. Both families have very simple bodies, with no pro-legs and fully formed unretractable head capsules. Stratiomyid larvae can grow to around 20 mm, while psychodids are usually smaller than 10 mm long.

Possible misidentifications

No other dipteran larvae are as heavily sclerotised as moth and soldier fly larvae. Recently moulted or pale psychodids can look a bit like ephydrids, but psychodids will have each of their segments sub-divided and the edges of the sclerites should be visible even if they haven't darkened.

Classification and distribution

Both families are fairly diverse with over 50 species each, but their taxonomy is still under review and these numbers are likely to increase.

Habitat and ecology

Psychodids occur in a range of habitats, from rotting logs, wet soil and mud to shallow water. The fully aquatic species are usually found in still or slow-flowing water. Psychodid larvae eat decaying organic matter and microalgae. The stratiomyids occur in similar habitats and eat similar food. Both families are usually tolerant of organic pollutants and some psychodids are known to thrive in sewage treatment plants.

Natural history

Adult psychodids are odd-looking flies that aren't often seen, except around blocked drains when they signal the need for a plumber. They have hair-covered wings and antennae, and are thought to be one of the more primitive families of Diptera.

Pschodid larvae are found in shallow, nutrient-enriched waters. Some of them are semi-terrestrial or found in rotting wood.

Stratiomyids often float. Their abdomen ends in a ring of water-repellent hairs that breaks the water surface and helps them breathe air through their spiracles.

Black flies (Family: Simuliidae)

Distinguishing characteristics

Black fly larvae have elongate, pear-shaped bodies, with a 'suction disk' at one end and a pair of feathered mouthparts at the other. They hold onto rocks and other solid objects in fast-flowing water and filter food particles from the water with their mouthparts. Older larvae have a single pro-leg with small hooks, and a 'gill spot' on either side of their thoracic segments. Simuliids move in a leech-like manner, using their 'suction disk' and a single thoracic pro-leg. The can reach 8 mm in length.

Possible misidentifications

Simuliid larvae superficially resemble leeches in their shape and movement. Their head capsules distinguish them from leeches, while their peculiar body shape easily separates them from other fly larvae.

Classification and distribution

Three genera, *Simulium*, *Austrosimulium* and '*Paracnephia*' occur in temperate Australia, with fewer than 100 species. The taxonomy of this group has proven problematic, with animals that appear the same proving to be genetically distinct species and animals that appear different turning out to be genetically similar.

Habitat and ecology

Simuliids are filter feeders in fast-flowing water.

Natural history

The suction cup at the end of a simuliid's abdomen is more complicated than it first appears. The edge of the cup is actually surrounded by a band of small hooks that catch on a silk mat that the larvae spin onto the rock. If larvae are knocked free by rough water, or if they have to flee a predator, they let out a silk lifeline that stops them being washed away. Silk also plays a part in the pupal phase. Just before pupating, the larvae spin a small 'hammock' that will hold the pupal case in fast water. The pupal hammock narrows downstream so that the pupal case is safe from being dislodged by the flow, but the upstream opening is wide enough to let the mature pupa escape easily when it is ready to float to the surface and emerge. Given all these uses, it is not surprising that black fly larvae have silk glands that stretch the length of their bodies.

Black fly larvae choose a place to attach themselves based on the speed of the water flowing over it. They use their fan-like mouthparts to filter the water as it flows past.

Adult black flies will sometimes bite humans, but it is thought that, like mosquitoes, it is only females that require a blood meal—before they lay their eggs.

Family: Tanyderidae

Distinguishing characteristics

The tanyderids are elongate larvae with a broad, flat, sclerotised head capsule, a single pair of posterior pro-legs and a number of long fleshy projections that are attached to their final segments and pro-legs. Tanyderids can grow to around 20 mm.

Possible misidentifications

See Chironomidae and Ceratopogonidae.

Classification and distribution

There are three genera of tanyderids in temperate Australia: *Eutanyderus* and *Nothoderus* from south-eastern Australia and *Radinocerus* from Western Australia. None are common.

Tanyderids are fairly rare, wood-boring larvae.

Habitat and ecology

Tanyderid larvae are woodborers that occur in cool wood-filled streams.

Family: Thaumaleidae

Distinguishing characteristics

The thaumaleids have a sclerotised head capsule and a long simple body with a single anterior and a single posterior pro-leg. The first thoracic segment has a pair of small sclerotised spiracles. When disturbed, thaumaleids move with a sideways bend, like slow dixids. Thaumaleids can grow to around 10 mm.

Possible misidentifications

See Ceratopogonidae (page 119) and Chironomidae (page 120).

Classification and distribution

Thaumaleids are fairly rare and are represented by the genera *Austrothaumalea* and *Niphta*.

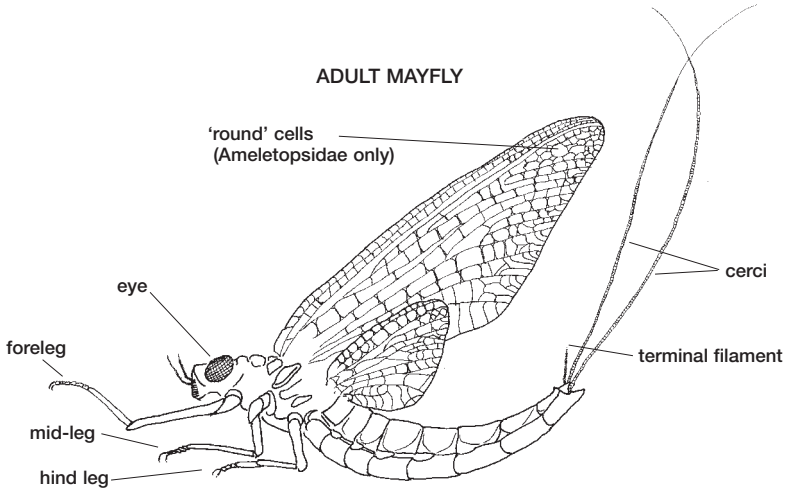
Thaumaleids are chironomid-like dipterans that occur in splash zones near waterfalls and cascades.

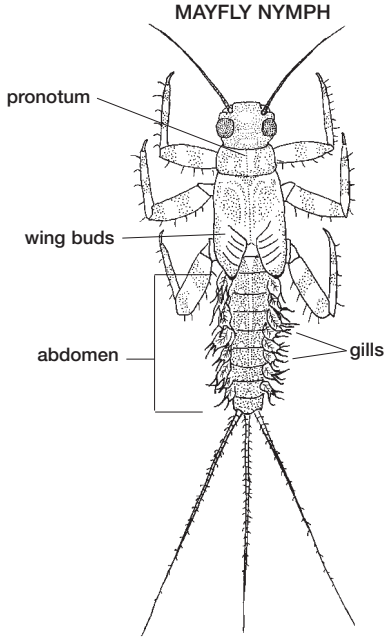
Habitat and ecology

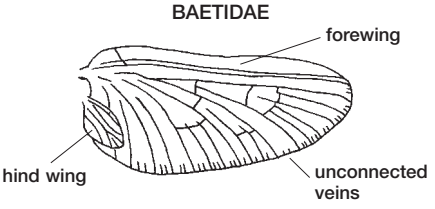
Thaumaleids are grazers in wet areas near waterfalls and other fast-flowing habitats.

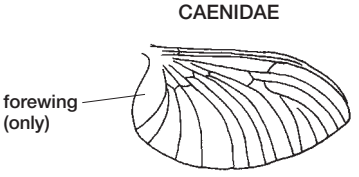
Mayflies (Order: Ephemeroptera)

The mayflies are one of the more well-known stream insects. Their invertebrate fame is the result of their short lives as adults and their tendency to end up as fish food. The adults are a common sight, swarming over water during the warmer months.









Characteristics of an adult

Adult mayflies have large compound eyes and most have two pairs of wings. The front wing is always much larger than the hind wing and they are held together vertically above the body when the animal is at rest. Most mayflies have three cerci or tails, though in some species (some *Atalophlebia* for example) the middle one is reduced or lost. Mayflies are the only aquatic insects to have two winged stages. Immediately after emerging, mayflies are dull grey with opaque wings. This stage is referred to as the sub-imago, or 'dun' if you are a fly fishing enthusiast. Sub-imagos are fairly placid animals, biding their time amongst streamside vegetation until the next moult. The sub-imago stage lasts about a day. During the next moult, adults lose a layer from each of their wings which then become transparent. This is the final and sexually mature stage known as the imago or spinner. These are the animals involved in swarming, mating and laying eggs. Most adults are short lived, lasting only a matter of days or even hours. They do not feed and in some animals, the digestive system is replaced with air-filled spaces that are thought to help the animal to balance during flight.

This female baetid has lost its cerci, leaving it with a single terminal filament.

Characteristics of a nymph

Mayfly nymphs are distinguished by their three tails (two cerci and a terminal filament) and the set of gills on each side of their abdomen. Different families of mayfly have these organised differently and some have protective covers (Caenidae and Oniscigastridae). They have well-developed jointed legs, antennae and wingpads. Flattened nymphs tend to live in faster flowing environments and move with rapid scurried movements sticking close to the stream bed. Rounded nymphs are usually strong swimmers and can move through the water like small fish. Often they propel themselves by strokes of their tails, which are fringed with swimming hairs.

Austrophlebioides is a common mayfly nymph in streams throughout eastern Australia.

Sexing mayflies

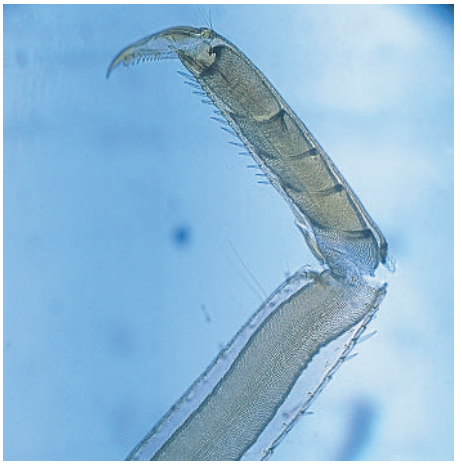
Male mayflies are often quite easy to distinguish from females by their split eyes and overly long forelegs. Both of these structures are used during mating. The split

eyes give the males excellent visibility in multiple directions and this allows them to manoeuvre into a suitable mating position with a female while in flight. Usually this involves the female flying into a swarm of males and being approached from below. The long forelegs are useful at this stage, as they reach forward and grasp the female at the base of her wings. Mating can take place in midair, or the couple can sometimes adjourn to a nearby landing site. The split eyes of the male are evident in some nymphs during their final aquatic stages.

Male mayflies have split eyes, long forelegs and a small pair of claspers immediately beneath their tails.

The sub-imago or dun

Mayflies are the only aquatic insects known to go through two winged adult stages. The sub-imago stage is a bit of a mystery and there are two theories put forward for its existence. The first is that it is a primitive condition that has gone unchanged because it is useful. The sub-imago skin is covered with lots of microscopic structures that resist wetting and this can assist an animal that is struggling to free itself from the water. The alternative explanation focuses on the long legs and tails of adults and it is thought that two stages are required to allow the legs to grow as long a they do. It would be difficult for the front legs to increase to three or four times their original length in a single moult.



A final instar mayfly nymph foreleg. The adult leg, with a double claw and multiple tarsal segments is packed tightly inside.

The sub-imago of *Atalophlebia albiterminata* has distinctively patterned wings.

An adult *Nousia* strains to free itself from the extra layer of skin that it wore as a sub-imago.

Mayflies and the evolution of flight

Insects did most of their evolving between the Upper Carboniferous (260 mya) and the Mid Cretaceous periods (80 mya). The more recently evolved insect groups include the true flies (Diptera) and the moths and butterflies (Lepidoptera), while the more primitive groups include the dragonflies (Odonata) and mayflies (Ephemeroptera). These more primitive winged groups can be recognised by the fact that they haven't developed a way of folding their wings out of the way when they aren't using them.

Atalophlebia albiterminata basks in the sun after shedding its sub-imago skin.

Mayflies provide a link to the first crude attempts at wings and flight. It was originally thought that wings evolved from stiff projections on the thorax of some terrestrial insect, but the gills of an aquatic mayfly nymph's ancestor provide a much more likely precursor. Fossil insects have been found with gill-like structures on their thoracic segments Like wings, these gills were movable, and had a well-developed vein network. These structures would have originally helped with movement underwater, but they would also work as crude gliding wings when insects moved back onto land. Wings didn't develop properly however, until the late Carboniferous. At this time land plants had become quite large and offered lots of opportunities for insects to jump from great heights and finetune their recently evolved wings.

Mayflies and compleat anglers

The mayfly is arguably the most important insect in fly fishing. Artificial flies have been designed to imitate many of the commoner species and often they are even designed to replicate a particular part of their lifecycle. Some wet flies sink to imitate mayfly nymphs. Others float just beneath the water surface—they mimic emerging mayflies at a vulnerable stage, struggling at the surface while they inflate their newly formed wings. Dry flies rely on their feathers to keep them on top of the water surface. These flies can have pale wings to imitate sub-imagos, clear wings for imagos, and flat wings splayed out on the surface to imitate spent mayflies, dead upon the water surface after they have laid their eggs.

Environmental significance

Most mayflies occur in places with good water quality, although some families are more tolerant than others. The taxonomy and tolerances of most families within this group are relatively well known, so they can be very useful in environmental assessment. Some of the more tolerant genera include *Atalophlebia* (family Leptophlebiidae) and *Tasmanocoenis* (family Caenidae).

Classification

Seven families of mayfly are found in temperate Australia. Of these, the most diverse, common and widespread are the families Leptophlebiidae and Baetidae. Currently, there are around 30 genera and 100 species recognised in temperate Australia. Mayfly taxonomy is still in progress throughout the region, so these numbers are likely to increase.

Key to families of mayfly nymphs

1 one set of abdominal gills larger than others, and covering them **2**
1 not as above **3**

2(1) gills on abdominal segment 1 enlarged, elliptically shaped ..... **Oniscigastridae** (p. 142)
2 gills on abdominal segment 2 enlarged, square shaped ..... **Caenidae** (P. 138)

3(1) nymph moves with characteristic 'rocking horse' motion; gills V-shaped, and spine covered ..... **Coloburiscidae** (p. 139)
3 not as above **4**

4(3) flattened nymphs; setae on their tails arranged in sparse whorls; cling to the undersides of rocks, wood and plants. ..... **Leptophlebiidae** (p. 140)
4 rounded nymphs; hairs arranged on tails as a dense fringe; fringed tails make these animals strong swimmers **5**

5(4) gills split, with the upper leaf plate-like and the lower feathery ..... **Ameletopsidae** (p. 136)
5 gills single or if split, both parts similarly plate-like **6**

6(5) antennae shorter than head width; gills with a hardened edge and strut ..... **Siphlonuridae** (p. 143)
6 antennae longer than head width; gills without a hardened edge or strut ..... **Baetidae** (p. 137)

Key to families of mayfly adults

1 hind wing obviously greater than 1/3 the length of the forewing **2**
1 hind wing smaller than 1/3 the length of the forewing, or absent **5**

2(1) wings pink-purple, and/or with a cluster of cells near the apex that have more than 5 sides ..... **Ameletopsidae** (p. 136)
2 wings clear, grey, yellow or brown, and all cells with a maximum of five sides **3**

3(2) 3 tails (2 cerci and one terminal filament) ..... **Siphlonuridae** (p. 143)
3 2 tails **4**

4(3) small mayfly (found near lakes and slow-flowing parts of rivers) ..... **Oniscigastridae** (p. 142)
4 large mayfly (found near pebble /cobble streams and rivers) ..... **Coloburiscidae** (p. 139)

5(1) with hind wings **6**
5 without hindwings **7**

6(5) hind wings very small, margin of forewing with numerous unconnected marginal veins ..... **Baetidae** (most) (p. 137)
6 hind wings smaller than 1/3 the length of forewing, all marginal veins connected ..... **Leptophlebiidae** (p. 140)

7(5) forewings with very few cross veins, all marginal veins connected ..... **Caenidae** (p. 138)
7 forewings with cross veins, some marginal veins unconnected ..... **some Baetidae (*Bungona* and *Cloeon*)** (p. 137)

Killer mayflies, purple perils (Family: Ameletopsidae)

Distinguishing characteristics

Ameletopsids are large mayflies; the nymphs are dark and shiny with large heads and robust bodies. They have large gills with the upper part plate-like and the lower part split into many fine filaments giving it a feathery appearance. The outer cerci are densely fringed with hairs on their inner margin, while the central tail or terminal filament has both sides fringed. These fringes of hair help propel them quickly through the water. Nymphs can exceed 20 mm. The adults have robust yellow-brown bodies, sometimes with bright pink-purple wings. A close look at the forewings will reveal a cluster of cells near the tip, that are less square than others and can have up to six or seven sides. The cells on most mayfly wings have five sides or less (usually four) and this makes them roughly rectangular.

Possible misidentifications

The Siphlonuridae and Baetidae may appear similar, but they both have a single plate-like gill, rather than the two-part, plate-like and tufted gills of the Ameletopsidae.

Classification and distribution

The family Ameletopsidae is represented by a single genus, *Mirawara,* in temperate Australia. Three different species occur along the east coast, but the family is entirely absent from Tasmania and Western Australia. Other genera from this family are found in New Zealand and South America.

Habitat and ecology

Mirawara is found in fast-flowing cobble streams. It is a nocturnal predator with long teeth on its mandibles. It feeds on smaller invertebrates such as mayflies and chironomids.

Mirawara **is the only predatory mayfly nymph in Australia.**

Adult *Mirawara* are one of the largest Australian mayflies. This female measured over 20 mm long.

Natural history

Adults are found from October to April and do not exhibit a strongly synchronous swarming behaviour. To compensate for this, they are probably slightly more long-lived, to increase the chances of individuals finding a mate.

Baetids (Family: Baetidae)

Distinguishing characteristics

The Baetidae are small to medium-sized mayflies (<10 mm) with rounded bodies and mottled colourings. Their heads are well rounded and bear a pair of long antennae. They have paired or single plate-like gills on their abdominal segments and fringes of setae on their tails. Baetids are strong swimmers and move with rapid wiggles of their abdomen. The adults are small, fragile animals with heavily reduced or absent hindwings. Their forewings have fewer strong cross-veins than other mayflies and the posterior wing margin is lined with short, unconnected vein endings.

Possible misidentifications

Nymphs of both the Ameletopsidae and the Siphlonuridae look a bit like the Baetidae. Ameletopsids can be separated by their size, robustness and their plate and tufted gills. The siphlonurids have antennae that are shorter than half the length of the head and each of their gills is reinforced with a hardened strut and margin. Baetids have longer antennae and their gills lack reinforcing.

Classification and distribution

The Baetidae is a diverse family with a world-wide distribution. In temperate Australia, they are represented by five described genera: *Bungona*, *Centroptilum*, *Cloeon*, *Offadens* and *Edmundsiops*. The last two are the result of ongoing taxonomic work that will reclassify the old genus *Baetis*. There are around 16 recognised species, but this is likely to increase as the taxonomy is resolved.

A baetid nymph, showing its plate-like gills.

Baetids are fast swimmers; their streamlined shape reduces water resistance.

An adult female baetid (left) and a male (right). The male's eye is clearly divided, and its front legs are very long for grabbing females in flight.

Habitat and ecology

Baetids are more diverse in cooler, flowing waters, but species do occur in warmer lowland systems and sometimes even in wetlands. They mainly feed on algae grazed from a variety of substrates, including rocks, wood and aquatic plants.

Natural history

Most male mayflies have their eyes split into an upper and a lower lobe, but these structures are very well developed in the Baetidae. Male baetids have what is referred to as a turbinate eye. These structures have a huge upper lobe and a smaller lower lobe, giving the head a turban-wearing appearance. As with other mayflies, these eyes are thought to help with the difficult task of aerial mating.

Baetids often have several generations living in the water simultaneously and different species emerge at different times of the year, so emergence for the family is spread through the warmer months between August and May.

Family: Caenidae

Distinguishing characteristics

Caenid nymphs can be recognised by the gills on the second abdominal segment being modified into square flaps covering the other gills. These flaps are thought to protect the delicate gills from being clogged with fine sediment. Their body is flattened and is only around 5–6 mm long. They are often covered in hairs and fine algae, giving them a fuzzy appearance. Some live animals can have a pinkish colour, but most are grey-brown. Caenid adults retain the stocky bodies of the nymph when they emerge. Their most notable feature however, is the absence of hind wings and the almost total lack of cross-veins in the forewings.

Possible misidentifications

Oniscigastrid nymphs share the characteristic gill covers of the caenids, but oniscigastrids are larger and their body is not flattened but streamlined. Oniscigastrid gill covers are oval, rather than square, and located on the first abdominal segment rather than the second.

Classification and distribution

Caenids are found in most parts of the world, with the odd exception of New Zealand. The family is represented in temperate Australia by three genera, *Tasmanocoenis*, *Wundacaenis* and *Irpacaenis*, and around 10 species.

A slow-moving caenid nymph is often overlooked due to its small size and camouflage.

Adult caenids have stocky bodies and short, rounded wings. They lack hind wings.

Habitat and ecology

Caenids are associated with slower flowing, silty areas of streams and standing waters. They are more pollution-tolerant than other groups of mayflies and feed on detritus.

Natural history

Adults of *Tasmanocoenis* can form swarms at the edge of streams in the early morning. Caenids have one or two generations a year. The adults emerge in spring and summer. Caenids are poor swimmers and mostly crawl along the riverbed, or around macrophytes. In the United Kingdom, this family goes by the name 'angler's curse' due to the fact that their small size makes them difficult to mimic with flies and yet they are a really important source of trout food.

Caenid nymphs are often covered in silt and algae, which adds to their camouflage.

Stream horses, spiny nymphs (Family: Coloburiscidae)

Distinguishing characteristics

Their common names well reflect the appearance of coloburiscid nymphs. The most distinguishing characteristics are the spiny 'V' shaped gills and the hunched body. Their quick, nodding swimming motion is reminiscent of a galloping horse. The two front pairs of legs have very long hairs and the mouthparts are adorned with various brushes. Each spiny gill has a secondary branch which forms a basal tuft of filaments. Nymphs also have a pair of small finger-like gills, one on each side of their mouth. The cerci are densely covered with hairs and are used to propel the animal through the water. Coloburiscid adults are large, dark coloured mayflies, with substantial hind wings and a reduced, or absent, central tail (terminal filament).

Possible misidentifications

The unique shape of their gills makes it difficult to confuse coloburiscid nymphs with other mayflies.

Classification and distribution

A single genus of the Coloburiscidae is present in the highlands of south-eastern Australia. *Coloburiscoides* includes three described species. This family is also found in New Zealand and South America, but does not occur in Tasmania, Western Australia or northern Australia.

Coloburiscids use their distinctive spines to anchor themselves between rocks in the stream.

Habitat and ecology

Coloburiscid nymphs live in fast-flowing, upland streams. They use the spiky gills to anchor themselves under rocks and resist being swept away by the flow. Their spiky appearance makes it tempting to think that they are predators. However they are harmless filterfeeders and collect organic particles from the stream current using mouthparts equipped with brushes and the first two pairs of legs fringed with long hairs. The nymphs live mostly on or under rocks and submerged woody debris.

Natural history

The nymphal stage lasts between six months and two years and the adults emerge between November and March. Sub-imagos are thought to emerge in the late evening and wait for the following day before moulting to the imago stage and swarming the following evening.

Leptoflebs (Family: Leptophlebiidae)

Distinguishing characteristics

Leptophlebiid nymphs can be quite varied in their appearance, but they all have flattened bodies and heads, flattened legs with broad femurs, and prominent gills along the sides of their abdomen. Usually these are paired and vaguely leaf-like. The setae on their tails are arranged in rings, or whorls along their length and the edges of some abdominal segments have small, but well-developed backward pointing blades. Most nymphs are smaller than 20 mm. Adult leptophlebiid mayflies are very variable, but all have the hindwings smaller than a third the length of the forewings. They can have two or three tails and come in a range of sizes.

Leptophlebiid nymphs are flat to avoid being swept away in fast-flowing rivers.

Possible misidentifications

Very few other mayfly families are as distinctly flattened as the leptoflebs. The caenids are flattened, but their distinctive gill covers should distinguish them fairly easily.

Classification and distribution

Leptophlebiidae is Australia's most diverse mayfly family. Leptophlebiids occur worldwide and are the dominant group in Australia, New Zealand and South America. They are currently represented in temperate Australia by 19 genera and 70 species.

Atalophlebia has feathery gills and lives in slow-flowing water.

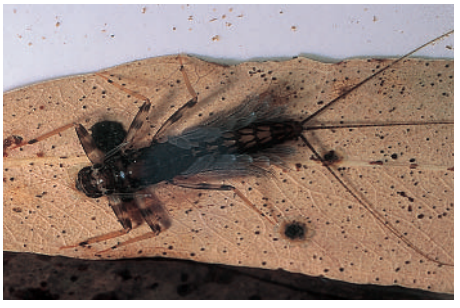
Habitat and ecology

Most leptophlebiids probably collect detritus from the surface of rocks and wood. They usually occur in fast-flowing streams, though *Atalophlebia* is typically found in slower flowing or still water amongst wood and aquatic plants. The horned leptophlebiid, *Jappa,* and some *Ulmerophlebia* are burrowing nymphs that tunnel in gravelly, sandy or silty stream beds. They feed on a mixture of algae and collected detritus.

Natural history

Some leptophlebiid genera have distinctive physical characters that shed some light on the way they live. *Jappa* has a pair of horns on its head that helps it while burrowing in softer sediments. *Atalomicria* has very long maxillary palps with brushes on their ends that are distinctive and might be involved in collecting detritus. *Kirrara* has broad gills that form a skirt-like suction cup around the abdomen, which helps it cling to rocks in fast-flowing water. *Atalophlebia* has feathery gills that increase the surface area available to extract oxygen from the slow-flowing waters in which it lives. Many of the other genera such as *Nousia*, *Austrophlebioides* and *Tillyardophlebia* are superficially similar, but their broad, flattened bodies and gill-lined abdomens are ideal for life on the edges of cobbles in fast-flowing water.

Many of the flies used by Australian fly fishing enthusiasts are based on leptophlebiid adults. Common patterns include red spinners (*Atalophlebia australis*), black spinners (*Atalophlebia albiterminata*) and various duns (sub-imagos of *Atalophlebia* sp.). These are all mayflies that are common in the broader rivers and lakes where trout have been introduced.



Atalomicria has an elongate pair of mouthparts for collecting detritus.

Jappa, one of the strangest leptoflebs, uses its robust horns while burrowing in soft sediments.

A sub-imago struggles free from its nymphal skin at the water surface.

A leptophlebiid adult male has enormous eyes that take up most of its head.

Family: Oniscigastridae

Tasmanophlebia nymphs have their first pair of gills enlarged to cover the rest. This possibly protects them from silt.

Distinguishing characteristics

Oniscigastrid nymphs have streamlined bodies around 12–15 mm long. Their first pair of gills forms oval flaps covering the following gills. They have a row of small dorsal spines along the mid-line of their first five abdominal segments. Their cerci have a fringe of hairs. Adults have large hind wings and two tails.

Possible misidentifications

See Caenidae (page 138).

Classification and distribution

The Oniscigastridae is represented in south-eastern Australia by a single genus, *Tasmanophlebia*, with three species. This family also occurs in New Zealand and South America.

Habitat and ecology

Nymphs live in slow-flowing streams and in still water bodies. They prefer sandy riverbeds and feed on detritus.

Natural history

Nymphs leave the water just before emerging as sub-imagos crawling on to rocks and boulders at the edge of the stream. Most oniscigastrids complete one or two generations a year. The bulk of these emerge as adults between November and March.

Family: Siphlonuridae

Distinguishing characteristics

Siphlonurid nymphs are robust, with a body length to about 15 mm. They have the gills on their abdominal segments reinforced with a hardened outer margin and by a hardened strut running through the middle of each gill. Their antennae are shorter than half the length of the head. Their cerci are densely fringed with hairs and are used for swimming. Adults are large dark mayflies, with three tails and large hind wings.

Possible misidentifications

See Baetidae.

Classification and distribution

The Siphlonuridae is represented by a single species, *Ameletoides lacusalbinae,* which is restricted to the cold water of alpine areas in south-eastern Australia and Tasmania.

Habitat and ecology

Siphlonurid nymphs live in small alpine streams and some lakes in the Kosciuszko region. They scrape algae from hard surfaces such as rock or wood.

Natural history

Nymphal development lasts up to two years and the adults emerge from September to January. Siphlonurids are a good indicator of fish-free streams and disappear almost entirely from streams with large predatory fish in them such as large *Galaxias* or introduced trout species. Much of their susceptibility to fish predation comes from their habit of grazing the tops of rocks in the pools of streams during broad daylight. This sort of behaviour is sensible only in the absence of trout!

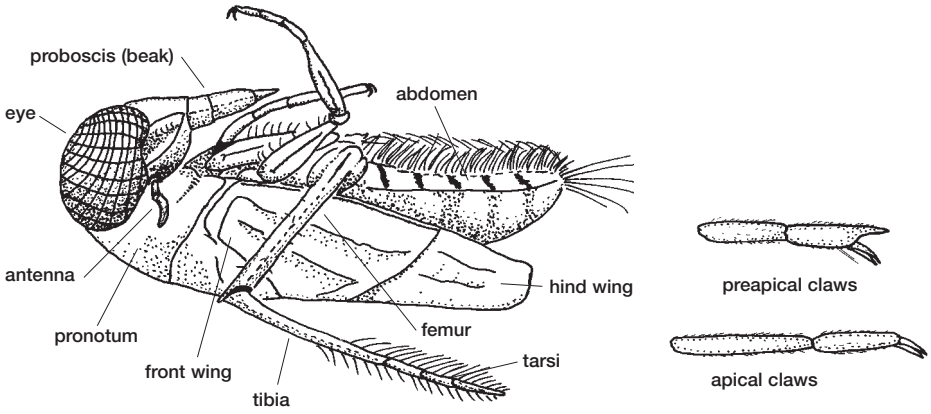
Siphlonurids look like baetids, but they are much bigger and have shorter antennae.

Ameletoides lacusalbinae grazes on detritus on the tops of rocks in the pools of upland streams.

True bugs (Order: Hemiptera, Suborder: Heteroptera)

Although the term 'bugs' is often used as a nickname for all insects, true bugs are hemipterans, belonging to the suborder Heteroptera. There are around 270 aquatic or semi-aquatic species in Australian inland waters—many people will have heard of backswimmers, water striders or waterboatmen.

BACKSWIMMER



Characteristics of aquatic and semi-aquatic bugs

The hemipteran body varies from elongated and boat-shaped in backswimmers to leaf-like in water scorpions. Adult forms range from a tiny 1 mm (small water striders and velvet water bugs) to 75 mm (giant water bugs).

The hind legs of some families (waterboatmen, backswimmers) are widened and covered by 'swimming' hairs while the long hind and middle legs of water striders are specialised to support the animal on the surface of the water. Some groups have unusually folded forelegs specialised for grasping prey in the same manner as praying mantises.

One feature common to all aquatic and semi-aquatic bugs is their piercing and sucking mouthparts. Adults and nymphs from this group look very similar. Nymphs lack wings and are smaller.

Piercing mouthparts are characteristic of all aquatic bugs, from the 30 mm giant water bug (left) to the 1 mm small water strider (right).

This water strider (Family: Gerridae) will sink if pollutants reduce the surface tension of the water.

Members of the Ochteridae are usually found only at the edge of aquatic habitats.

Living on different levels

The true bugs are an interesting group because of the many different ways that they live in and around water. Some families such as the notonectids and corixids are fully aquatic and spend most of their time under water, while other families such as gerrids and veliids spend most of the their time on the water surface. Sometimes the surface dwellers will compete with the fully aquatic bugs for prey, and a struggling insect ensnared in the water film has an equal chance of being dragged under the water and consumed, as being plucked from the film and sucked dry above the water surface. Many more families are semi-aquatic and live along the water margins, splitting their time between the water surface and dry land. Most fully grown bugs have well formed wings and will eventually fly away from the water where they grew up, to colonise new water bodies.

Environmental significance

Hemipterans are relatively tolerant of many forms of pollution. Surface dwellers in particular have very little physical connection with water and therefore are less dependent on the water quality. However, oil and surfactants (e.g. household detergents) decrease the surface tension of the water and this reduces the ability of the surface dwellers to repel water with the hydrophobic hairs on their legs, thus causing them to sink.

Classification

Hemiptera is a common and diverse order. In Australia it includes over 5650 species from three different suborders. Aquatic and semi-aquatic hemipterans belong to the largest suborder Heteroptera, which includes some 270 different species from 19 different families, of which two families, Hermatobatidae and Omaniidae, are exclusively marine. Many species are endemic to Australia but most of the genera occur in other parts of the world. In this book we include 12 families that are both strongly associated with freshwater and relatively common. The Saldidae Ochteridae, Dipsocoridae, and Leptopodidae have not been included though they might sometimes be found in streams and lakes after heavy rain, while members of the aquatic Aphelocheiridae occur only in northern Australia.

Love, death and music

The males in several groups (e.g. Corixidae, Notonectidae) produce sounds to attract females. This is called stridulation and involves them rubbing the pegs on their front legs across a ridge on the front of their head. The males of some water striders (Family: Gerridae) express their feelings by making rhythmic ripples on the water.

Copulation occurs in the water or on the water surface and eggs are laid on the surface, inside aquatic plants or on the bottom of a water body. Belostomatid eggs are laid on the male's back. This protects them from both the male and other predators.

With the possible exception of some water-boatmen (Family: Corixidae) which consume a mixture of detritus and zooplankton, all aquatic bugs are predators. They use their piercing mouthparts to suck the body fluids from their prey. Surface dwellers such as water striders catch terrestrial insects that have fallen into the water; backswimmers chase small creatures in the water and water scorpions ambush their prey.

Hemipterans do not have a pupal stage and their nymphs look and behave in a similar way to the adults. Young nymphs face a real possibility of being eaten by adults and this is a good reason to stay clear of their parents.

Waterboatmen make sounds by rubbing the pegs on their front legs across a ridge on the front of their head.

An immature backswimmer looks and behaves in a very similar way to an adult backswimmer.

Key to Hemiptera

1 antennae as long or longer than head, clearly visible from above; animals live on water surface or amongst fringing vegetation; semi-aquatic **2**

1 antennae shorter than head; animals live in water or around the edge of water bodies; aquatic or semi-aquatic. **6**

2(1) body long and slender; head as long as thorax ..... **Water measurers** (**Hydrometridae**, page 153)

2 head and body stouter; head not as long as thorax **3**

3(2) femora of hind legs extending well beyond tip of abdomen; gap between the front and mid-legs greater than that between the mid and the hind legs ..... **Water striders** (**Gerridae**, page 152)

3 femora of hind legs not extending well beyond tip of abdomen; gaps between the front, mid and hind legs are all equal; body shorter than 5 mm **4**

4(3) winged forms with scutellum covered by the pronotum; wingless forms with pronotum covering mesonotum or not; tarsal claws preapical ..... **Small water striders** (**Veliidae**, page 159)

4 winged forms with scutellum exposed behind pronotum; wingless forms with pronotum never covering mesonotum; tarsal claws apical **5**

5(4) hind legs longer than body length; winged and wingless forms present; tarsi 3-segmented; generally greenish or yellowish in colour ..... **Water treaders** (**Mesoveliidae**, page 159)

5 hind legs shorter than body length; only winged forms known in Australia; tarsi 2-segmented; short dense body hairs giving 'velvet' appearance ..... **Velvet water bugs** (**Hebridae**, page 159)

6(1) antennae completely hidden; body and head broad with a pair of widely separated eyes positioned at front of head; forelegs with broad femur, specialised for grasping; semi-aquatic; up to 10–11 mm long ..... **Toad bugs** (**Gelastocoridae**, page 151)

6 without the above combination of characters; aquatic **7**

7(6) elongate non-retractile breathing tube present at tip of abdomen; ..... **Water scorpions** (**Nepidae**, page 155)

7 abdomen without elongate breathing tube, but short, retractile air straps may be present **8**

8(7) tarsal segments of first pair of legs scoop-like; head appearing triangular from the front ..... **Waterboatmen** (**Corixidae**, page 149)

8 without the above combination of characters **9**

9(8) forelegs modified for grasping; swim the right way up **10**

9 forelegs are not modified for grasping; swim with ventral side up **11**

10(9) membranous part of forewings with veins; adults 10–15 mm long; edges of body with dark and light bands ..... **Creeping water bugs** (**Naucoridae**, page 154)

10 membranous part of forewings without veins; adults around 25–75 mm long; body uniform brown ..... **Giant water bugs** (**Belostomatidae**, page 148)

11(9) adults around 4–10 mm long; eyes large, close together; body elongated; hind legs oar-like; common. ..... **Backswimmers** (**Notonectidae**, page 157)

11 adults 2–3 mm long; eyes smaller, not close together; body highly convex; hind legs normal; less common ..... **Pygmy backswimmers** (**Pleidae**, page 158)

Giant water bugs (Family: Belostomatidae)

Distinguishing characteristics

Giant water bugs have flattened bodies, strong raptorial grasping forelegs, and hind swimming legs fringed with hairs for a powerful stroke. The species of *Lethocerus* from northern and eastern Australia can reach 75 mm in body length. These are the largest hemipterans in Australia. Voracious predators, they may become a nuisance in fish farms. The genus *Diplonychus*, found over much of northern and eastern Australia, is smaller and reaches around 30 mm in length. It is advisable not to catch these bugs with your bare hands as they can inflict a painful bite with their powerful beak.

Possible misidentifications

See Naucoridae (page 154).

Classification and distribution

Two genera, *Lethocerus* and *Diplonychus,* are found in Australia. *Diplonychus* includes just two species, one of which, *Diplonychus eques,* is common in south-eastern Australia.

Habitat and ecology

Belostomatids live in wetlands, ponds and lakes that have plenty of aquatic vegetation. They are good swimmers and can chase after their prey over a short distance. They spend most of their time hanging in the water column waiting for an opportunity to catch prey. With their imposing size, belostomatids are often at the top of the food chain and are one of the few invertebrates that can readily feed on small fish.

Natural history

The female *Diplonychus* lays her eggs on the back of a male. In this position they are safe from the male and other predators. The male shows tender love and care by stroking the eggs with his hind legs to maintain a fresh flow of water. However, if an egg gets dislodged he readily eats it! It remains a mystery whether the egg-carrying male is actually the 'father' of the prospective offspring.

The genus *Diplonychus* is found over much of northern and eastern Australia.

A belastomatid devouring a fly caught from the water surface.

A male *Diplonychus* with eggs on his back.

As in many other groups of aquatic bugs, belostomatid nymphs stay away from their parents to avoid being eaten.

Males have been reported to make stridulatory sounds to attract females.

Belostomatids have been seen communicating with each other by rhythmical push-up-like body movements near the surface of the water.

Waterboatmen (Family: Corixidae)

Distinguishing characteristics

Waterboatmen are slightly flattened bugs with a streamlined body form. Their mouthparts are in the form of a short, blunt, triangular rostrum, unlike the long sharp beak of the majority of other aquatic bugs. Their hind and middle legs are fringed with swimming hairs, while their forelegs are short and scoop-like. One peculiar feature of male corixids is their asymmetrical abdomen—some sclerites on the underside of the abdomen are much larger on one side than the other. Females, however, are perfectly symmetrical. Adults range in size from 1.5 to 15 mm long.

Possible misidentifications

Corixids can be confused with backswimmers (Notonectidae). When alive these groups are easy to distinguish as notonectids swim with their legs uppermost while corixids swim in the ordinary fashion with their legs held underneath their bodies. If the animal is dead, check its back: the back of a corixid is dark and flat, while that of a notonectid is lighter in colour and much more convex. The corixid beak is short and triangular.

Classification and distribution

Thirty one species and five genera of waterboatmen are known from Australia.

Waterboatmen are slightly flattened bugs with a streamlined body form.

Like other corixids, *Sigara* sp. carries an air bubble around its abdomen.

Although only around 5 mm in size, *Micronecta* is a very common and abundant genus.

The most common genera are *Sigara* and the much smaller *Micronecta*. Corixids are distributed throughout Australia with the exception of the genus *Diaprepocoris,* which occurs mainly in the southern half of Australia.

Habitat and ecology

Corixids occur in slow-moving or still waters among aquatic vegetation. Often they are the most common insects in ponds and at the edges of lakes and slow-flowing streams among vegetation. They are excellent fliers and can easily move from one water body to another.

The food of corixids is a combination of other insects such as mosquito larvae and bits of vegetation which they grind up internally. Because of their abundance, corixids themselves are a good source of food for fish.

Natural history

Adult males of *Sigara* produce chirping sounds—or stridulations—to attract females. They do this by rubbing their front femora, equipped with special pegs, against the sharp edge of their head. Some *Micronecta* species stridulate with their abdominal segments. Females attach eggs to submerged objects. Nymphs look similar to adults but without wings. They moult five times before becoming mature adult waterboatmen.

The air reservoir of corixids consists of a bubble of air over the exposed abdominal surface and beneath the wings. The air is replenished through spaces between the head and pronotum by the animals breaking the surface film with the pronotum.

Toad bugs (Family: Gelastocoridae)

Distinguishing characteristics

Toad bugs are rather bizarre-looking bugs. With their wide prothorax, bulging eyes and the ability to suddenly jump on their prey, they really justify their name. Their forelegs are scythe-like with widened femora adapted for grasping and holding prey. Adults have wings but rarely fly. They are around 10 mm long.

Possible misidentifications

None.

Classification and distribution

Twenty species from the single genus *Nerthra*, are found throughout Australia.

Habitat and ecology

Gelastocorids live on the edges of still water bodies and can crawl in and out of the water. They prefer moist conditions, such as in rainforests, and may be found at a considerable distance from water.

Toad bugs are predators. They crawl around slowly looking for suitable victims.

Toad bugs crawl in and out of the water.

When they find something, they quickly jump on it, dispatching it with their needle-like mouthparts.

Natural history

Gelastocorids represent an early evolutionary stage when aquatic bugs began to colonise the freshwater environment, and this is why they are comfortable in or out of water. Males of some *Nerthra* species from the northern hemisphere can produce sounds to attract females.

Toad bugs don't turn up very often.

Water striders (Family: Gerridae)

Distinguishing characteristics

Water striders have long middle and hind legs, at least three times longer than their forelegs. They hold their forelegs close to their body and spread their middle and hind legs on the water surface, often giving the impression that they have only four instead of six legs. Like other surface bugs, they are covered in a coat of unwettable hairs. The hydrophobic hairs on their tarsi, together with their preapical claws, help them to stay on the surface film without breaking through it. Their body has a spindle-like shape; adults have wings and can fly. They are usually darkly coloured and around 8 mm in length. Their leg span can be more than 50 mm.

Possible misidentifications

See Veliidae, Mesoveliidae and Hebridae (page 159).

Classification and distribution

Four subfamilies and at least 36 species are known from Australian inland waters, although most of this diversity is in tropical waters. Of these, the subfamily Gerrinae and the genera *Tenagogerris* and *Aquarius* are common in south-eastern Australia. *Tenagogerris* is endemic to Australia. Three genera have colonised marine environments.

Habitat and ecology

Gerrids occur in small or large groups on the surface of ponds, lakes, and the edges of wetlands or slow-flowing rivers. They are extremely difficult to collect (and photograph!) as they have excellent eyesight and, when approached within a metre or so, tend to skate away. Gerrids are active predators and sense their prey using ripples on the water surface. Once they have trapped an aquatic insect or other invertebrate, they stab it with their beak.

Cannibalism is not uncommon and the juveniles stay together keeping a safe distance from their hungry parents. Often cooperation takes place and several individuals, sometimes even from different species, hunt together—like wolves in a pack—to capture a larger prey.

Natural history

Males and females communicate by making rhythmic ripples on the water surface. A male will use ripple signals to attract a female and stimulate her when she responds, as well as to tell other males to stay away from his mate.

Water striders occur in a variety of habitats, including slow-flowing rivers.

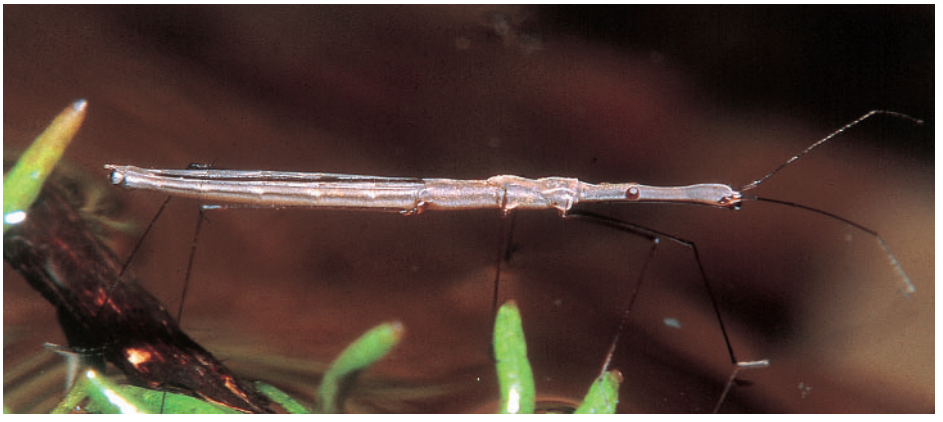
Some water striders such as this *Rheumatometra* from Tasmania have a more rounded body shape.

Mating behavior is complex, ranging from monogamy, when a male stays with his female protecting her from other males, to polygamy when males try to mate with as many females as possible.

Sometimes males get together to display for females and the 'best' male gets to mate more than others do—this is called 'polygyny'. Eggs are deposited on floating objects or sometimes underwater.

The ability of gerrids to spread their weight and skate on the water surface is so impressive that in some parts of Canada they are called 'Jesus bugs'.

Water measurers (Family: Hydrometridae)



Water measurers have a delicate and comical look about them.

Distinguishing characteristics

An elongated head and a stick-like body makes 'water measurers' look like yardsticks for measuring water surface. With eyes positioned halfway up the long head and antennae mounted at its end, these animals look both delicate and comical. Hydrometrids are usually pale brown and rather cryptic. Their slow movement and slender limbs allow them to blend in with vegetation on the water surface. Fully grown animals rarely exceed 15 mm.

Possible misidentifications

Their peculiar appearance makes it very hard to confuse them with any other group.

Classification and distribution

All nine species of Australian hydrometrids belong to the genus *Hydrometra*. *H. strigosa* is one of the most common species. Both the family and the genus are found throughout the world.

Habitat and ecology

Hydrometrids live on the surface of the water at the edges of wetlands, lakes and ponds, often hiding amongst vegetation. They are normally slow-moving animals but can move rapidly when disturbed. They feed or scavenge on small animals fallen on the surface of the water. Surface-dwelling springtails are one of their favourite foods.

Natural history

The lifecycle of Australian hydrometrids has not been studied intensively. In other parts of the world they have been observed to have 5 instars (immature stages) and become adults in 4–6 weeks.

Creeping water bugs (Family: Naucoridae)

Distinguishing characteristics

Creeping water bugs have a flattened oval body and head. Their forelegs are modified for grasping with robust femurs and simplified tibiae and tarsi for holding the body of their prey. Most species have a striped pattern along their sides. The length of the adult is less than 11 mm.

Possible misidentifications

Naucorids look similar in general shape to belostomatids. They also have very similar forelegs. Adults can be separated by size, as belostomatid adults are at least 25 mm long. Distinction is more difficult when it comes to juveniles. Belostomatid nymphs have bulging eyes and pointy heads, while the naucorids have eyes that fit within the outline of their blunt-shaped heads.

Naucoris is the only genus of Naucoridae found in Australia.

Creeping water bugs catch and hold their prey with their raptorial legs.

Classification and distribution

Naucoris is the only genus of Naucoridae found in Australia. There are six species of which *Naucoris congrex* is common in south-eastern Australia.

Habitat and ecology

Despite their name creeping bugs are very good swimmers and inhabit still and slow-flowing waters. Like other hemipterans, they are predators. They catch and hold their prey with their raptorial legs.

Natural history

Male naucorids can produce stridulatory sounds to attract females. Nymphs undergo five moults and look similar to adults. Adults have wings and can quickly disperse from one water body to another. Creeping water bugs rely on atmospheric oxygen and have to come up to the surface to renew their air supply from time to time.

Water scorpions and needle bugs (Family: Nepidae)

Nepids are separated into two groups: water scorpions (left) have a leaf-like body, while needle bugs (right) have a stick-like body.

Distinguishing characteristics

Nepids occur in two forms: one with a broad leaf-like body (water scorpions) and the other with a stick-like body (needle bugs). Both forms have pincer-like forelegs adapted for seizing prey and a long, thin breathing tube at the tip of the abdomen. This breathing tube is made up of two rod-like structures and is extended above the surface of the water. It acts like a snorkel, giving the animal a supply of air, without it constantly having to re-visit the surface.

Possible misidentifications

Some wide-bodied nepids could be confused with belostomatids but only the nepids have a breathing tube.

Classification and distribution

Water scorpions are placed in the subfamily Nepinae, with a single genus *Laccotrephes*. Needle bugs are placed in the subfamily Ranatrinae, with four genera, *Ranatra*, *Goondnomdanepa*, *Austronepa* and *Cercotmetus*. The genera *Ranatra* and *Laccotrephes* are common throughout Australia. The genera *Goondnomdanepa* and *Austronepa* are endemic.

Habitat and ecology

Nepids occur in a variety of wetlands and ponds among debris and aquatic vegetation where their body is well camouflaged. Only the genus *Goondnomdanepa* from the tropical north of Australia has been found under rocks in flowing water. Nepids crawl around slowly and are poor swimmers. If disturbed, they can slowly paddle through the water.

Nepids ambush unsuspecting prey with a quick grasping action of their forelegs.

Nepids can easily catch fast-swimming animals.

Their two large eyes give them excellent sight and they can easily catch fast swimming animals such as waterboatmen or small fish, killing their prey quickly by stabbing it with their beak-like proboscis.

Natural history

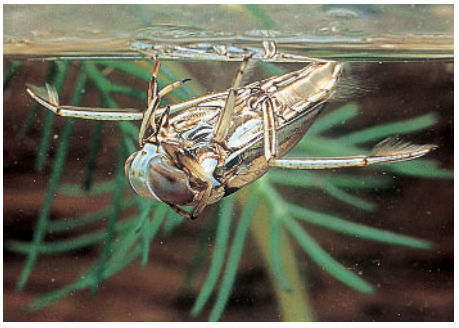
Males can produce sounds to attract females. The female lays her eggs into decaying wood or in soft plant stems. Nymphs go through five moults before reaching the adult stage. Despite their size and cumbersome appearance, nepids are surprisingly quick to colonise new water bodies. They can sometimes be found in roadside ditches and other temporary ponds after flooding.

Sit-and-wait predators

Water scorpions (Family: Nepidae) look like a piece of vegetation or a stick and they rely on being inconspicuous. Like all hemipterans, they breathe air, but regularly swimming to the surface would reveal their camouflage to their prey. These animals have come up with an elegant solution. They use a snorkel-like breathing tube at the end of their abdomen. The breathing tube, although quite long, rarely exceeds the length of the animal's body. So what restricts the length of the breathing tube? If the breathing tube is too long, the exhaled carbon dioxide will not escape from the tube and will prevent oxygen from getting in. For the same reason humans cannot use a longer snorkel to swim in deeper water.

Water scorpions use a snorkel-like breathing tube at the end of their abdomen.

Backswimmers (Family: Notonectidae)



The name backswimmers reflects the unusual way these insects swim (*Enithares* sp.).

Backswimmer nymphs look much like adults: often they have a very light-coloured back.

Distinguishing characteristics

Backswimmers can be recognised by their convex backs and their large eyes, which occupy most of the head. Their hind legs are elongated and modified for swimming with fringes of hair that help to push them through the water. Their name reflects their unusual behaviour of swimming upside down, performing a kind of backstroke. As a result of this switch in swimming style, the back of some notonectids is light-coloured so that the animal is not conspicuous against the light of the sky. Some hover mid-water in search of prey. This behaviour means that they are often the first animals to be spotted in ponds. Adults range from 4 to10 mm long.

Possible misidentifications

Immature backswimmers coud be confused with their smaller relatives, pygmy backswimmers. However, adult pygmy backswimmers are less than 3 mm long and have a much rounder body than notonectids.

Backswimmers can sometimes be confused with waterboatmen (see Corixidae).

Classification and distribution

In Australia, the family Notonectidae includes six genera of which *Enithares* (5 species) and *Anisops* (30 species) are the most common.

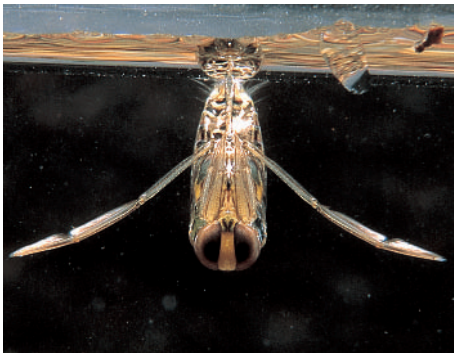
Habitat and ecology

Backswimmers are common in all still and slow-flowing water bodies. They fly easily and can therefore colonise new ponds and wetlands quite quickly. They are predators feeding on a mixture of invertebrates from the open water and the water surface.

Natural history

Backswimmer males can produce sounds to attract females. Eggs are often deposited into water plants. Juveniles look like adults and behave in a similar way. However, one of a nymph's prime tasks is to avoid being eaten by its parents.

Backswimmers breathe atmospheric oxygen and, although they carry a bubble of air on the underside of their abdomen, they have to come to the surface to renew their supplies from time to time. Some notonectids such as *Anisops* have a blood pigment similar to



Anisops carrying a reflective bubble of air on the under side of its abdomen.

ours, which is very efficient at carrying oxygen. They can therefore carry smaller bubbles than other bugs and remain neutrally buoyant. This allows them to hunt mid-water, without sinking or constantly returning to the surface. Their upside down bodies and grasping forelegs allow backswimmers to hunt animals that have fallen on the water surface.

Backswimmers are very active predators and in the northern hemisphere there are reports of them attacking small fish. They can inflict a painful stab or bite—so handle them with care!

Pygmy backswimmers (Family: Pleidae)

Distinguishing characteristics

As their name suggests, pygmy backswimmers look very much like small backswimmers (Notonectidae). However, they have a highly convex body, are less than 3 mm long, and lack the oar-like hind legs of notonectids. They are much less common than notonectids and, due to their small size, are often overlooked in samples.

Pygmy backswimmers can be recognised by their small size, convex body and widely separated eyes.

Possible misidentifications

See Notonectidae (page 157).

Classification and distribution

Three species of the widespread genus *Neoplea* are described in Australia but only two occur in south-eastern Austrtalia.

Habitat and ecology

Pygmy backswimmers can be found in still water bodies among aquatic vegetation. Often they prefer to crawl among vegetation rather than swim. They prey on zooplankton, tiny animals smaller than themselves, and carry a bubble of air under their wings on the ventral side of their abdomen.

Natural history

Little is know about the lifecycle of pygmy backswimmers in Australia. Nymphs look similar to adults.

Small water striders, water treaders and velvet water bugs (Families: Veliidae, Mesoveliidae and Hebridae)

These three families are combined because of similarities in their appearance and habitat.

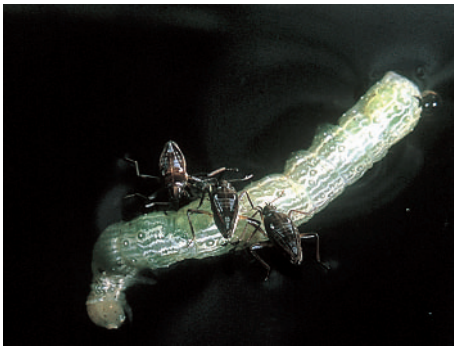
Distinguishing characteristics

These are small bugs (1–4.5 mm) with relatively short legs. Tufts of hydrophobic hair at the tip of their tarsi hold them on the water surface while in Veliidae the claws are also inserted preapically. Non-winged adult forms occur among Veliidae and Mesoveliidae, making it difficult to distinguish between immature and adult stages, but the nymphs always have only one segmented tarsi. Unlike the gerrids (water striders) which skate or scull across the water surface, members of these families either walk or run.

Possible misidentifications

Members of these families can be confused with the water striders. However, water striders have long middle and hind legs with the femora of both the middle and hind legs extending well beyond the edge of the body. Gerrids can also be recognised because the gap between their front and middle legs is greater than the gap between their middle and hind legs. Veliidae can be distinguished by preapical claws and, in winged forms,

Small water striders (Family: Veliidae) have both winged and wingless adult forms.



Small water striders (Family: Veliidae) prey and scavenge on small invertebrates fallen on the water surface.

Water treaders (Family: Mesoveliidae) have hind legs longer than their body.

the scutellum is covered by the pronotum. Hebridae and Mesoveliidae both have apical claws and the scutellum exposed behind the pronotum in winged forms. Hebridae have 2-segmented tarsi and hind legs shorter than the body, while Mesoveliidae have 3-segmented tarsi and hind legs longer than the body.

Classification and distribution

Veliidae has 12 genera and some 66 species in Australia. Five genera occur in south-eastern Australia with *Microvelia* being the most common and diverse genus.

Mesoveliidae in Australia has two genera, *Mesovelia* (widespread) and *Austrovelia* (north Queensland), but only *Mesovelia* is semi-aquatic. *Mesovelia hungerfordi* is common in south-eastern Australia.

Hebridae in Australia has two genera, *Hebrus* and *Merragata,* with one species of each common in south-eastern Australia.

Habitat and ecology

These semi-aquatic bugs are all surface or edge dwellers and can be found in still and slow-flowing waters. They prey and scavenge on small invertebrates fallen on the water surface. Like the larger water striders these groups can detect their prey by vibrations on the surface of the water.

Natural history

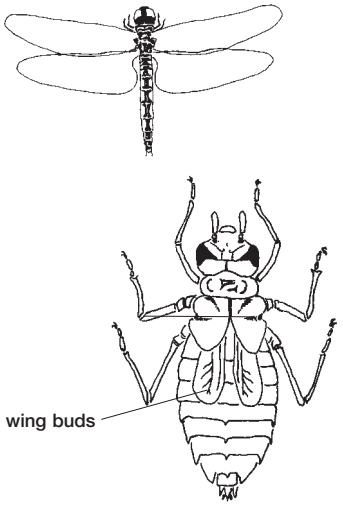
The lifecycle comprises five moults. Veliidae and Mesoveliidae have winged and wingless forms of adults while Hebridae are only known as winged forms. Winged mesoveliids are sometimes found with the membranous part of their wings ripped off. This is possibly to get the wings out of the way before mating takes place.

Dragonflies and damselflies

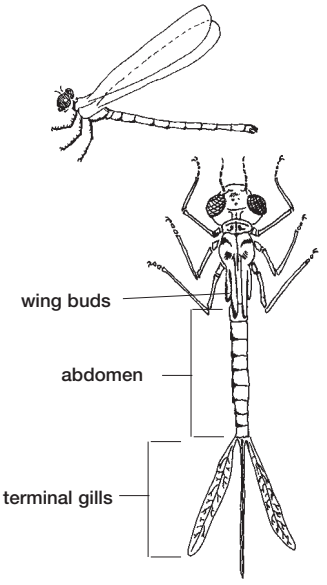
(Order: Odonata, Suborders: Epiproctophora and Zygoptera)

The odonates are one of the best-known group of freshwater invertebrates. They have a special place in human history, appearing in Japanese art, English literature, and even ancient Greek writings.

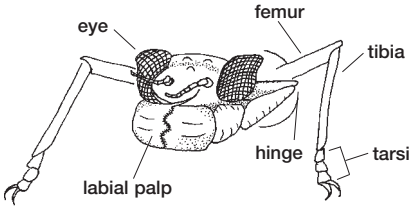
EPIPROCTOPHORA (DRAGONFLIES)



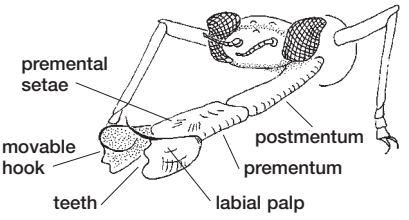
ZYGOPTERA (DAMSELFLIES)



ODONATE MOUTHPARTS (UNEXTENDED)



ODONATE MOUTHPARTS (STRIKING)



Characteristics of an adult

Adult dragonflies and damselflies are a colourful and obvious part of freshwater systems. They have a rather distinctive shape, with a highly fused thorax and an elongated abdomen. The thorax contains the musculature to power four large wings, which are responsible for the animal's incredible flight speed (around 50 km/h). Odonates are also exceptionally controlled fliers (compared to the hectic flight of the caddisflies for example) and this allows them to be one of the most efficient aerial predators in the insect world. Large eyes, long, spine-covered legs and large mouthparts help them dispatch prey such as butterflies and smaller dragonflies while on the wing.

Characteristics of a larva

Despite having wing buds, the juvenile stage is usually referred to as a larva, not a nymph, but either name is recognised. All dragonfly larvae are predatory. They tend to be slow-moving predators that rely on camouflage together with the strike from their remarkable mouthparts to catch prey. Their jaws are long, hinged structures that fold up underneath the head. Unextended, the mouthparts have a pair of labial palps (paired lower lips) that are either pointed and rest below the mandibles (upper jaws), or flat and cover the mouthparts totally forming a 'mask'. The mask is characteristic of the corduliid and libellulid-like dragonflies. In both cases, the palps are armed with teeth and these are used to

Hemicordulia tau is a common dragonfly throughout temperate Australia.

Ischnura heterosticta is a common damselfly throughout Australia and the Pacific.

Austroaeschna sp. is a common aeshnid-like dragonfly larva found in temperate Australian streams.

Austrolestes psyche is a typical lestid damselfly larva, with a slender abdomen and well-developed terminal gills.

grasp prey when the mouthparts are extended during a strike.

Telling dragons from damsels

Dragonflies tend to be more stockily built than damselflies and, as a general rule, resting dragonflies hold their wings flat on either side of the body, while damselflies hold their wings pressed together over their backs. There are a few exceptions to this rule, such as the Megapodagrionidae and the Diphlebiidae. Both these damselfly families adopt the pose of a dragonfly, but they are too slender to be confused with dragonflies. A failsafe way to separate the two groups is to look closely at the animals. The hind wings on dragonflies are broader than their forewings, while the forewings and hind wings of damselflies are of similar width. The eyes on damselflies are widely separated when viewed from above, while dragonfly eyes usually touch or nearly touch in the middle of their heads. Larval damselflies are more slender than dragonflies and have three long gills attached to the end of their abdomen. Dragonflies are notably stockier and have their gills inside their abdomen.

Jet bugs

Larval dragonflies breathe by sucking water into their abdomen where it reaches their internal gills, then squeezing it out. Threatened by a larger predator—such as a fish or a Waterwatch volunteer—they can squeeze the water out with enough force to jet propel themselves forward.

Mudeyes and coutas

Dragonfly larvae are often used by fishing enthusiasts, who have dubbed them 'mudeyes'. Mudeyes are usually from the corduliid/libellulid group of dragonflies, but the term can be used for all dragonfly larvae. The aeshnid larvae sometimes get the separate name 'coutas', possibly because of their sleek, predatory, barracuda-like looks.

Adult dragonflies have their eyes close together and hold their wings flat. This is *Hemicordulia tau*.

Adult damselflies have their eyes separated by roughly an eye-width, and usually hold their wings together vertically above their backs. This is *Synlestes weyersii*.

Ancient history

The oldest odonate fossils have been recovered from rocks from the Carboniferous period (320 mya). These animals were often quite large: one genus, *Meganeura,* had a wingspan of around 60 cm. This is large enough to carry off a small mouse! Dragonflies and damselflies are unable to fold their wings over their abdomen and this feature suggests that they are an ancient and relatively primitive group. Mayflies are a similarly primitive

group, whereas true flies, such as tipulids and midges, are considered quite advanced among the winged insects.

Environmental significance

Dragonflies and damselflies occur in a wide variety of habitats and some can withstand a range of environmental stresses. They are quite useful as indicators of environmental impact when studied at family (or lower) levels of taxonomy. A healthy stream, billabong or wetland usually supports a diverse range of odonates, while an impacted site may only boast a couple of the more pollution-tolerant species.

Pollution-tolerant odonates include the large *Austroaeschna unicornis*, *Hemicordulia tau* and the damselfly *Ischnura heterosticta*. These animals can be found in many urban streams and wetlands.

Classification

There are more than 300 species of Odonata recognised in Australia and these belong to 30 families, 22 of which occur in south-eastern Australia. Few of these families are totally endemic, though this is changing as the taxonomy is reviewed. Identification of some families within the Epiproctophora is difficult, so some of these families have been grouped based on similarities. The families and family groups covered in this text include:

Zygoptera (Damselflies):
Coenagrionidae, Diphlebiidae, Hemiphlebiidae, Isostictidae, Lestidae, Megapodagrionidae, Protoneuridae, and Synlestidae.

Epiproctophora (formerly Anisoptera) (Dragonflies):
aeshnid-like dragonflies (Telephlebiidae, Aeshnidae), corduliid/libellulid-like dragonflies (Austrocorduliidae, Cordulephyidae, Synthemistidae, Gomphomacromiidae, Hemicorduliidae, Urothemistidae and Libellulidae), Gomphidae and Lindeniidae, Petaluridae and the Primitive dragonflies (Archipetaliidae, Austropetaliidae).

Dragonfly larvae can often be identified by their characteristic mouthparts. *Austroaeschna unicornis* (left) has a flat prementum, while *Hemicordulia tau* (right) has a ladle-shaped prementum.

These examples of *Ischnura* are from different parts of a dam, the upper lived amongst green water plants, and the lower on dead wood.

Killer chameleons

Larval dragonflies hunt their prey either by stealthily stalking it, or by remaining totally still and waiting for it to move within range of their deadly mouthparts. A combination of colour and shape helps many dragonfly larvae to make themselves well camouflaged. Some larvae have mottled patterns to match their backgrounds and these can sometimes be altered if the background changes. Unlike chameleons, which can alter their colour patterns in a matter of seconds, dragonfly larvae can only change colour when they moult. Their colours mimic those around them and seem to set as the new skin hardens. Sometimes damselflies from the same species, in the same pond, can be brown or green depending on whether they spend their time on dead wood or aquatic plants. Some of the less active dragonfly larvae such as synthemids can incorporate algae into their camouflage.

A key to family groups of larval dragonflies and damselflies

1 slender larvae, with three terminal gills. Damselflies **2**
..... **(Suborder: Zygoptera)**
1 robust larvae, without terminal gills. Dragonflies **9**
..... **(Suborder: Epiproctophora)**

2(1) leaf-like terminal gills held flat and fanned out horizontally .....
..... **Megapodagrionidae** (page 171)
2 gills different in shape or orientation **3**

3(2) sack-like terminal gills ..... **Diphlebiidae** (page 168)
3 leaf-like, or simple terminal gills **4**

4(3) gills divided into two parts by constriction ..... **Isostictidae** (page 169)
4 gills complete, without constriction. **5**

5(4) larva small (14 mm) from swampy areas; prementum with 'paraglossae'; gills short
..... **Hemiphlebiidae** (page 168)
5 larva usually not quite so small when fully-grown, prementum without 'paraglossae', gills distinctly leaf-like **6**

6(5) leaf-like gills with raised mid-vein or rib ..... **Protoneuridae** (page 172)
6 leaf-like gills with mid-vein only slightly (if at all) raised **7**

7(6) gills shorter than last three abdominal segments ..... **Synlestidae** (page 173)
7 gills equal in length or longer than last three abdominal segments **8**

8(7) secondary veins in gills perpendicular (at right angles to) mid-vein; labial palps with many long teeth ..... **Lestidae** (page 170)
8 secondary veins in gills not perpendicular to mid-vein; labial palps simple .....
..... **Coenagrionidae** (page 167)

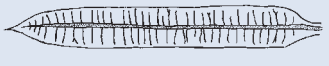
9(1) large larva (>40 mm); prementum with strong triangular, cleft, projection .....
..... **Petaluridae** (page 178)
9 smaller larva (usually <40 mm), prementum less distinct **10**

10(9) prementum ladle-shaped, forming mask in front of larva's face .....
..... **corduliid/libellulid-like dragonflies** (page 175)
10 prementum flat, folded under animal's 'chin' **11**

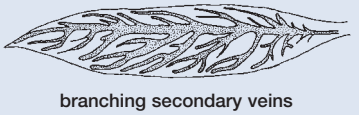
11(10) antennae with 4 segments, last segment enlarged and club-like; tarsi of at least foreleg and mid-leg with 2 segments .... **Gomphidae and Lindeniidae** (page 176)
11 antennae commonly with 5-7 segments; last segment rarely club-like; tarsi of all legs with 3 segments **12**

12(11) rounded triangular lumps along the sides of all abdominal segments except 9 .....
..... **Primitive dragonflies** (page 179)
12 sharp backward pointing spines on some abdominal segments, including 9 .....
..... **aeshnid-like dragonflies** (page 174)

TERMINAL GILLS (ZYGOPTERA)



perpendicular secondary veins



branching secondary veins

Suborder: Zygoptera, Family: Coenagrionidae

Distinguishing characteristics

Coenagrionid larvae typically have slender, brown or green bodies, sometimes with darker markings. Their gills are leaf-like and held vertically. Mouthparts: prementum not cleft; labial palps simple; movable hook of labial palp without setae, and multiple premental setae. Fully grown larval length can range between 13 and 30 mm for different species.

Possible misidentifications

The lestids appear similar, but usually have perpendicular veins on their gills and a more slender overall appearance. Some of the Protoneuridae are also similar, but they have a distinct rib on their gills. The synlestids can be separated by their cleft prementum and their shorter gills.

Classification and distribution

Nine genera occur throughout temperate Australia. They are often common animals with extensive distributions. *Ischnura aurora*, for example, also occurs in India and islands throughout the Pacific Ocean.

Habitat and ecology

Opportunistic species, such as *Ischnura aurora*, have life spans that can be as short as 8–10 weeks. This allows them to live full lives even when the temporary ponds they live in dry up after a couple of months.

Natural history

It is not uncommon for adult dragonflies and damselflies to be territorial, but some coenagrionids are territorial as larvae while still in the water. Rather than defending a mating ground, these animals appear to be defending hunting grounds.

Adult females of some species in this group can occur in two distinct colour patterns, one that resembles the males (andromorph) and another that is notably different (heteromorph). This strange arrangement is thought to protect the andromorph females from being overly harassed by males.

Typical coenagrionid larvae. Sometimes damselfly larvae lose their gills, but they grow back slowly, as they have on the green larva.

A mating pair of *Ischnura heterosticta*. The red and green male is holding the back of the female's neck with a pair of claspers.

Suborder: Zygoptera, Family: Diphlebiidae

Distinguishing characteristics

Diphlebiid larvae have thick, brown bodies and an overall 'chunky' appearance. Their gills are sack-like with furry tips. The dorsal surface of each abdominal segment has a patch of hairs. Mouthparts: prementum cleft; labial palps simple; four teeth on labial palp; no palpal and no premental setae. Fully grown larval length is 14–24 mm.

Possible misidentifications

No other damselflies in temperate Australia possess sack-like gills. Old preserved specimens of megapodagrionids may get puffy gills and superficially look the same but they lack the hairy back of the diphlebiids.

Classification and distribution

One genus, *Diphlebia*, with three species, is known from mainland south-eastern Australia. This family was formerly grouped with the family Amphipterygidae.

Habitat and ecology

Two of the three known species occur in flowing waters, on the undersides of large rocks, while the third is more commonly associated with slow-flowing rivers and detritus.

Larval diphlebiids have 'inflated'-looking terminal gills. [Photo: John Hawking]

Natural history

Adults from this group of damselflies adopt a very dragonfly-like pose when resting. However, their slender body and widely spaced eyes distinguish them from dragonflies.

Suborder: Zygoptera, Family: Hemiphlebiidae

Distinguishing characteristics

This is a small damselfly larva around 14 mm long, which holds its simple gills vertically. Mouthparts: prementum with curved spines ('paraglossae') centrally above a shallow cleft; labial palps with many long teeth.

Possible misidentifications

Young lestids may appear superficially similar with their many long teeth, labial palps and similar gills, but the paraglossae mentioned above are unique to the Hemiphlebiidae.

Classification and distribution

Only one species, *Hemiphlebia mirabilis,* is known. It is found in Victoria and a few places in northern Tasmania but is fairly uncommon.

Habitat and ecology

Hemiphlebia mirabilis occurs in ponds or temporary pools, usually in sandy catchments.

Natural history

This endemic species is placed in what is thought to be a primitive family, and has a very similar form to fossils from the Permian (250 mya). The adult is small and metallic green.

Hemiphlebia mirabilis. [Photo: John Trueman]

Suborder: Zygoptera, Family: Isostictidae

Distinguishing characteristics

Isostictid larvae have distinctly striped legs and dark to cream colouring. They hold their gills vertically and these are divided into two parts by a constriction. Mouthparts: prementum with protruding front margin, indistinctly cleft and with more than one pair of setae; labial palps with three teeth. Fully grown larval length is 17–22 mm.

Possible misidentifications

Preserved specimens without gills could be confused with a variety of other damselfly larvae.

Classification and distribution

Four species from four genera occur in mainland south-eastern Australia. The commonest of these is *Rhadinosticta simplex* (formerly *Isosticta simplex*). The family is also found in New Guinea and New Caledonia.

Rhadinosticta simplex is a striped larva, with divided gills, a characteristic that defines the family Isostictidae. [Photo: Karlie Hawking]

Habitat and ecology

Isosticitids occur in flowing waters, amongst vegetation or leaf litter.

Suborder: Zygoptera, Family: Lestidae

Distinguishing characteristics

Lestid larvae are slender, brown or green, with long leaf-like gills that are held vertically. The smaller veins of the gills appear perpendicular to the mid-vein. Often there is a dark band midway down the gill. Mouthparts: prementum distinctly cleft; labial palps with many long teeth, forming a basket of 'teeth' when closed; movable hook of labial palp with 2 setae; 7–8 pairs of premental setae. Fully grown larval length is 21–30 mm.

Possible misidentifications

See Coenagrionidae (page 167).

Classification and distribution

Only one genus, *Austrolestes*, is known from south-eastern Australia and is widely distributed.

Habitat and ecology

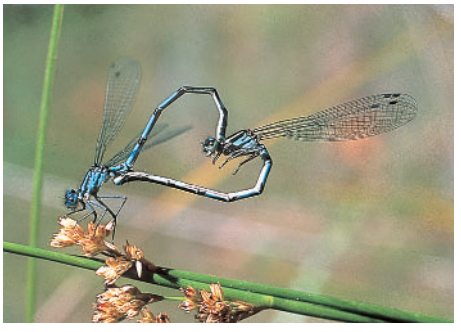
Lestids typically occur in slow-flowing waters and are often found around water plants.

Natural history

Some adult damselflies from this family will immerse themselves totally while laying eggs on water plants. If the male is still guarding the female from other males, both animals will submerge. Adult damselflies can remain submerged for around fifteen minutes and sometimes perish underwater after laying their eggs.

Austrolestes sp. slowly stalks its prey, in this case a small midge larva.

With mouthparts unextended, *Austrolestes analis* shows its distinctive basket of interlocking teeth.



As these mating pairs of *Austrolestes cingulatus* age, their blue colours are replaced with green, gold and copper. The male holds onto his mate, often staying attached to her while she lays eggs.

Suborder: Zygoptera, Family: Megapodagrionidae

Austroargiolestes sp. makes its home in swampy areas.

Distinguishing characteristics

Larvae are usually brown with light or dark patterns. Their gills are broad and held horizontally. Mouthparts: prementum cleft; no premental setae. Fully grown larval length of *Griseargiolestes* is 15 mm; *Austroargiolestes* is 23 mm.

Possible misidentifications

No other damselfly larvae hold their gills flat like the megapodagrionids.

Classification and distribution

Two genera occur commonly in mainland south-eastern Australia, *Griseargiolestes* and the slightly larger *Austroargiolestes*.

Habitat and ecology

The Megapodagrionidae occur mainly in boggy, swampy areas.

Natural history

The commonest megapodagrionid from south-eastern Australia is *Austroargiolestes icteromelas*. Larvae are difficult to distinguish and many of the members of this family are only known as adults.

Austroargiolestes sp. shows its horizontal fan of gills, typical of megapodagrionids.

Adult megapodagrionids are common in the vegetation around swamps in early summer.

Suborder: Zygoptera, Family: Protoneuridae

Distinguishing characteristics

Protoneurid larvae are usually brown with contrasting light or dark patterns. Their gills are held vertically and have a distinct 'rib'. Mouthparts: prementum not cleft; labial palps with three teeth and some setae; movable hook of labial palp without setae and only one pair of setae on the prementum. Fully grown larval length is 25–28 mm.

Possible misidentifications

See Coenagrionidae (page 167).

Classification and distribution

One species, *Nososticta solida,* occurs in temperate Australia.

Habitat and ecology

Nososticta solida occurs in streams and rivers in areas of slow flow. Often found amongst water plants.

Natural history

The adults of this family are extremely slender-bodied and usually flaunt black-orange or black-yellow colour patterns.

The larva of *Nososticta solida* has its gills reinforced with a longitudinal rib. [Photo: John Hawking]

Suborder: Zygoptera, Family: Synlestidae

Distinguishing characteristics

Synlestid larvae are usually brown with light or dark patterns. Their gills are short and their antennae long with darker segments close to the head and lighter bands at the ends. Fully grown larval length is 25–28 mm.

Possible misidentifications

See Coenagrionidae.

Classification and distribution

Two genera of this endemic family are found in south-eastern Australia. *Episynlestes* occurs in rainforests in northern New South Wales, while the more-common *Synlestes* ranges throughout the area.

Habitat and ecology

Synlestids occur in a variety of habitats, usually with flowing water.

Natural history

The commonest members of this family are from the genus *Synlestes*. The larvae are stick-like and hold their bodies with a distinctly recurved posture. This mixture of colour and posture makes them perfectly camouflaged amongst woody debris and water plants. Effective camouflage helps them sneak up on prey, but also makes them much less visible to larger predators such as fish.

An adult *Synlestes weyersii*. Female odonates tend to have a bulbous end to their abdomen, while males often end in a pair of claspers.

Synlestes weyersii arches its abdomen in a scorpion-like manner, adding to its stick-like appearance.

Aeshnid-like dragonflies (Suborder: Epiproctophora, Families: Aeshnidae and Telephlebiidae)

Distinguishing characteristics

Aeshnid larvae come in a variety of colours, including reds, greens and browns, often with mottled patterns. They have large eyes and a stocky body. The abdomen usually has sharp backward pointing spikes on its sides (at least on segment 9). Mouthparts: prementum flat, with simple labial palps ending in a large movable hook and one tooth. Their antennae have 5–7 segments. Fully grown larval length is 30–40 mm (though some genera are slightly smaller).

Possible misidentifications

See Primitive dragonflies (page 179).

Classification and distribution

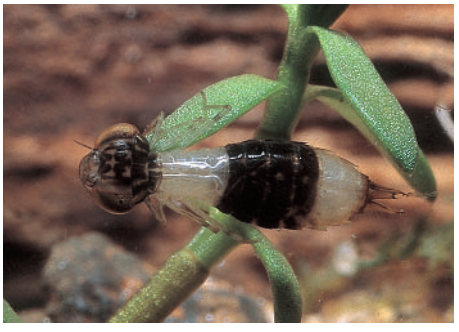
These two families were formerly grouped as the Aeshnidae, but they have now been separated. The Aeshnidae have a two-pronged central point to their abdomen, while the Telephlebiidae have a single point. True aeshnids often have setae on the dorsal surface of their labial palps. Both families are widely distributed throughout south-eastern Australia. Despite the recurrence of the word 'aeshna' in many of the generic names, most of the animals from this group now belong with the Telephlebiidae. The two families include 10 genera and 25 species from south-eastern Australia.

Habitat and ecology

These large predators inhabit both fast-moving and stagnant waters. They can be found on a range of substrates, from cobbles to water plants. The genera *Telephlebia* and *Antipodophlebia* can be found in damp litter near waterways rather than in them.

Natural history

The aeshnid-like odonates are some of the largest invertebrate predators in streams. They maintain this role as adults. Adults sport dull colours and are rarely still, spending most of their time on the wing, hunting and defending their territories against other dragonflies. Immature larvae can be dramatically striped.



Aeshna brevistyla has a striped pattern, and the central prong at the end of its abdomen has two points. This character separates the Aeshnidae from the Telephlebiidae.

Notoaeschna sagittata is one of the spikier aeshnid-like larvae.

Corduliid/libellulid-like dragonflies (Suborder: Epiproctophora, Families: Austrocorduliidae, Cordulephyidae, Synthemistidae, Gomphomacromiidae, Hemicorduliidae, Urothemistidae and Libellulidae)

Hemicordulia tau **is a sit-and-wait predator that lurks amongst the sediment and algae at the bottom of ponds.**

Distinguishing characteristics

Long thin legs give most of the members of this group a 'spidery' appearance. They are rounded animals, green to brown, often with mottled patterns. Many of them cultivate a layer of silt and algae over their backs. They have thin antennae with more than four segments. Mouthparts: prementum with labial palps forming a ladle-like structure folded under the head; labial palps may have a convoluted edge or be simple and with or without setae.

Fully grown larval length is highly variable. *Nannophya australis*, from New South Wales is around 8 mm while some of the larger synthemistids are around 26 mm long.

The Tasmanian synthemistid *Synthemiopsis* is a similar shape to the corduliids and libellulids, but is a lot hairier.

Possible misidentifications

This family group is very distinctive, and difficult to misidentify.

An adult *Procordulia jacksoniensis* spends most of its time hunting above the waters that it grew up in.

Nannophya dalei is one of Australia's smallest dragonflies, with a wingspan usually less than 40 mm.

Classification and distribution

This diverse group of families has had quite a turbulent history and, in the past, species have been included in Corduliidae, Synthemidae and Libellulidae. There are around 29 genera in south-eastern Australia, the commoner ones being *Hemicordulia* and *Eusynthemis*.

Habitat and ecology

This large group has representatives that occur in all aquatic habitats, but most of them are found in slow-flowing to stagnant water, amongst detritus, silt and water plants.

Natural history

Some members of this group are opportunists, capable of colonising temporary water and going through several quick generations, before the waters dry up. One such species, *Hemicordulia tau,* is also known to form large swarms of adults around bogs or wetlands.

While all big red dragonflies (in temperate Australia) are from the Libellulidae, not all libellulid dragonflies are big and red. This is a large and diverse family; the adults come in a variety of colours and patterns so there is no easy rule for recognising all of them.

Suborder: Epiproctophora, Families: Gomphidae and Lindeniidae

Distinguishing characteristics

Gomphid larvae are stocky, and brown, green, or lighter coloured. Sometimes they wear a film of fine detritus. Their antennae are 4-segmented and club-shaped, with the final segment enlarged. The pro- and meso-tarsus have two segments (most other dragonflies have three) and this is thought to make the legs more robust for digging through silt. Mouthparts: prementum flat, without cleft; labial palps simple, without setae. Lindeniids have distinctly round bodies. Fully grown larval length is 20–30 mm.

Possible misidentifications

Some of the Gomphidae may superficially resemble aeshnid-like larvae, but their antennae are always 4-segmented and truncated while their fore- and mid-tarsi are always 2-segmented.

Classification and distribution

The Lindeniidae was formerly part of the Gomphidae. One species, *Ictinogomphus australis,* occurs in mainland temperate Australia. It is found more commonly north of Sydney. The family Gomphidae is a diverse and widely distributed group of dragonflies found throughout temperate Australia. Ten species from three genera are known from temperate Australia, the commonest genus encountered is *Austrogomphus*.

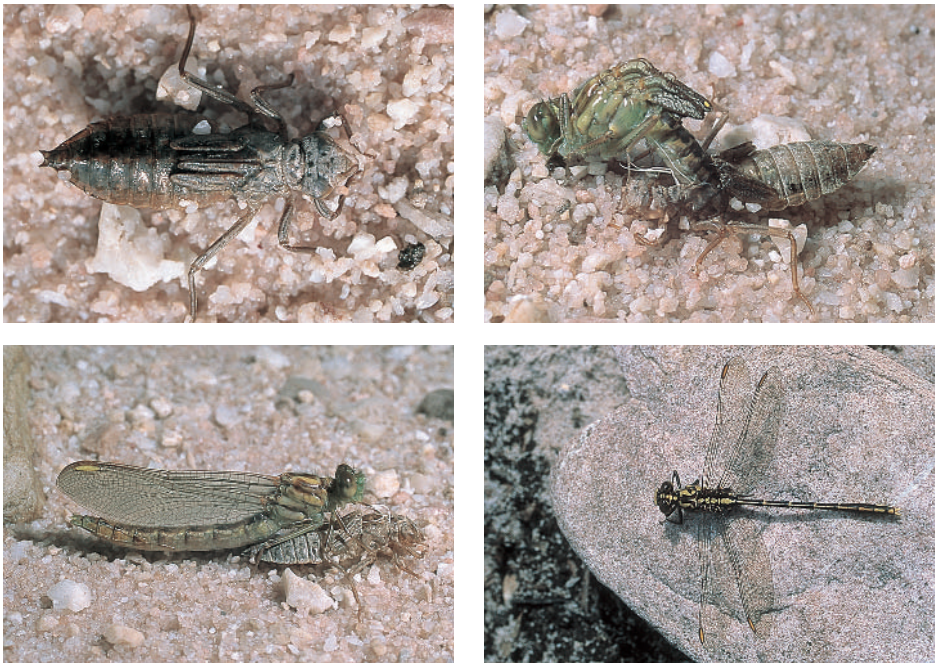
Habitat and ecology

These dragonflies inhabit sections of rivers with slower flows, often in areas where the substrate is covered with detritus. Some species occur in lakes.

Natural history

Gomphids are one of the few groups of dragonflies that can emerge from a horizontal surface. Most dragonflies climb up vertical sticks or reeds which allows them to 'fall' from their larval skin.

Most gomphid adults are black and yellow. They are 'perchers', surveying their territories from a lookout, which they will return to after reconnaissance flights and bouts of hunting.



Austrogomphus guerini **crawls from Lake Pedder, and emerges from its larval skin. A gomphid is the only odonate that doesn't need to hang from something when it emerges.**

Giant dragonflies (Suborder: Epiproctophora, Family: Petaluridae)

Distinguishing characteristics

The petalurids are the largest dragonflies in Australia. Larvae can be as long as 50 mm. Their abdomen lacks armouring and they have long antennae on an angular head. Mouthparts: prementum flat with a cleft triangular extension; simple labial palps.

Possible misidentifications

Large specimens are difficult to mistake for anything else, but care should be taken with smaller specimens.

Classification and distribution

Two species, *Petalura gigantea* and *Petalura litore,* are known from northern New South Wales. One species, *Petalura hesperia*, is found in Western Australia and another larger species, *Petalura ingentissima,* occurs in tropical Queensland. This group is as worthy of the title 'primitive dragonflies' as the next group, but they have been kept separate because of their size. The closest relatives of *Petalura* are found in South America.

Habitat and ecology

Petalurid larvae are semi-aquatic burrowers; they live in holes in swampy ground or beside streams.

Natural history

The petalurids are considered to be a strong link to the original dragonflies of the Carboniferous period, sharing many of the characteristics of ancient dragonflies, including their size. *Petalura gigantea* is the second largest dragonfly in temperate Australia. *Petalura ingentissima,* from tropical Queensland, is the largest in Australia, with a wingspan of up to 175 mm.

Petalura gigantea **leaves its burrow and climbs up a nearby reed before emerging as an adult. The claws of this empty skin are firmly stuck to the reed, allowing the adult to pull itself free.**

An adult male 'petal tail' (*Petalura gigantea*). Suitable swamp habitats for these animals are becoming rarer. [Photo: Caroline Dearson, Sydney Catchment Authority]

The world's largest odonate is *Megaloprepus coerulatus,* a damselfly from Central America, with a reported wingspan of 190 mm.

Primitive dragonflies (Suborder: Epiproctophora, Familes: Archipetaliidae and Austropetaliidae)

Distinguishing characteristics

The larvae of primitive dragonflies have prominent, blunt, triangular projections down both sides of the abdomen. They are often dark coloured with protrusive eyes. Mouthparts: prementum flat; without setae. Fully grown larval length is 30–40 mm.

Possible misidentifications

The aeshnid-like dragonflies can appear similar, but they have sharp, strongly backward pointing spines along the sides of their abdomens, rather than blunt triangular projections.

Classification and distribution

Two species of Austropetaliidae are found in New South Wales, both from the genus *Austropetalia*. The Tasmanian *Archipetalia auriculata* is the only species in the family Archipetaliidae. Formerly these species have been placed in the families Petaliidae and Neopetaliidae.

Habitat and ecology

Most of the larvae from this group are semi-terrestrial, living in splash zones or under damp logs at the sides of streams. Older larvae can be found slightly further from permanent water.

This emerging *Archipetalia auriculata* has just spent two years as a larva.

Natural history

All of these dragonflies are strong climbers and can be found several metres off the ground hanging from trees or rock faces, when they are getting ready to emerge. They are also renowned for 'playing possum' and can pretend to be dead indefinitely. Their diet includes most of the invertebrate life that can be found under logs and in the splash zones of waterfalls.

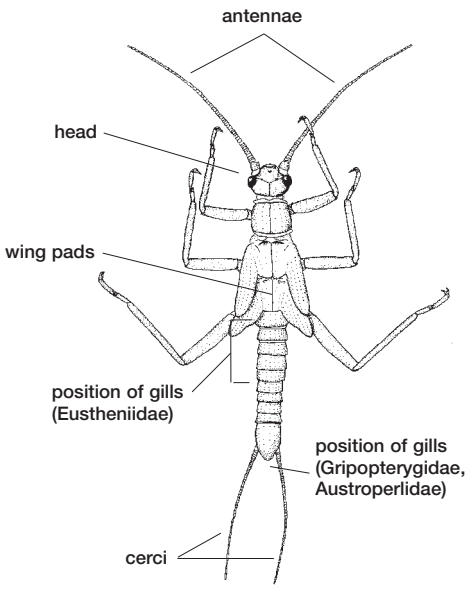
Archipetalia auriculata has spots and colour along the front margin of its wings.

The primitive dragonfly larva, *Archipetalia auriculata,* is semi-terrestrial.

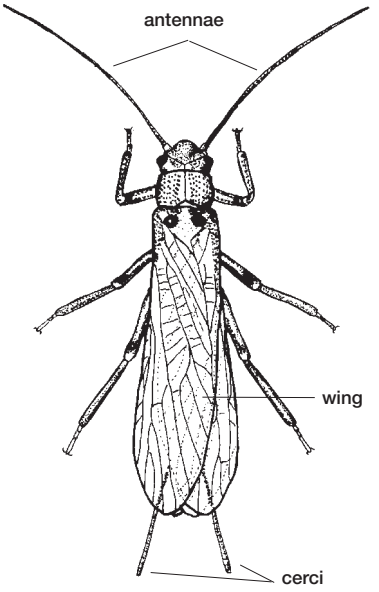
Stoneflies (Order: Plecoptera)

Stoneflies are a small, relatively primitive, group of insects. The nymphs are sensitive to water quality and are abundant in alpine streams.

GENERALISED STONEFLY NYMPH



GENERALISED STONEFLY ADULT



Characteristics of adults

Adult stoneflies are 5–60 mm long, with a soft, flattened body and four membranous wings folded above the body. Their colour is usually grey or brown, making them look inconspicuous, but some eustheniids have bright red, orange and black markings. Adult stoneflies are not very good fliers and therefore can be found close to creeks and rivers on surrounding vegetation where they mate before laying their eggs in the water.

Most adults emerge around spring or autumn and can live for up to a month. During this time they feed on organic matter such as rotten wood, lichen and algae.

Characteristics of nymphs

All stonefly nymphs are aquatic. They look similar to adults but have wing pads instead of wings. As with dragonflies and mayflies, the size of a stonefly nymph and its wing pads increases with every stage of

Adult stoneflies are usually inconspicuous, but eustheniids have bright red, orange and black markings.

Crypturoperla, an endemic Tasmanian, has inconspicuous gills but can be recognised by the tubercles on its abdomen.

A nymph of *Trinotoperla* showing a tuft of gills at the tip of its abdomen.

development. Stoneflies do not undergo a complete metamorphosis and the adults emerge from mature larvae after they have crawled from the water on twigs or stones. Nymphs and adults of most species, have a 3-segmented tarsus, long antennae and two cerci. Gripopterygid and austroperlid nymphs have gill tufts at the end of the abdomen. Nymphs use these gill tufts to breathe under the water. Most nymphs feed on detritus, but some species are carnivorous.

Classification

There are around 200 species of Australian stonefly belonging to four families (Eustheniidae, Austroperlidae, Gripopterygidae and Notonemouridae) which occur only in the southern hemisphere. Of the 26 Australian stonefly genera, 25 are endemic, while *Notonemoura* is also found in New Zealand.

Key to families of stonefly nymphs

1 no external gills at tip or sides of abdomen ..... **Notonemouridae** (page 186)
1 external gills at tip or sides of abdomen **2**

2(1) external gills on side of the abdomen; size often greater than 30 mm for fully grown nymph ..... **Eustheniidae** (page 184)
2 external gills at tip of abdomen only **3**

3(2) two long cerci present at the tip of the abdomen; numerous external gills form tuft at the tip of the abdomen; gills can sometimes be drawn inside the body ..... **Gripopterygidae** (page 185)
3 short cerci; three or five external gills only; genera *Acruroperla* and *Crypturoperla* have inconspicuous gills but can be recognised by tubercles on the abdomen ..... **Austroperlidae** (page 183)

Stoneflies as food for fish.

In alpine and semi-alpine streams stoneflies can occur in very large numbers. Fly fishers have long noticed that both nymphs and adults are very attractive food for trout and some species of native fish. Fish often feed on adult stoneflies as they run or 'skim' on the surface of the water. Many types of artificial 'fly' are designed to imitate stoneflies landing or falling on the water surface.

Fossil records

The first fossil record of stoneflies can be dated back to the early Permian period, approximately 290 mya. Modern families of stoneflies from the northern hemisphere can be identified from Baltic amber dated back to 38–54 mya.

Drumming

Adult stoneflies from the northern hemisphere communicate using 'drumming'—a beating and rubbing of their abdomen on the ground to create vibrations. Usually a male initiates drumming and then, if he is recognised, a female drums an answer. Drumming is thought to help males and females to find each other. The drumming frequencies are species specific and can be picked up by another insect eight metres away! Drumming is, as yet, unknown in Australian stoneflies.

The origin of flight

The behaviour of stoneflies can shed light on one of the theories of the origin of flight among insects. Some fossil arthropods have large gill plates on their body (like some mayflies). These gills could have served as prototypes to modern wings. How these weak gill plates were first used for flight remains a mystery, but they may have been used the same way stoneflies use their wings today. Many modern stoneflies 'skim' on the surface of the water using hairs on their legs to skate, while their wings propel them like hovercraft. Their wings do not require as much power for skimming as they do for flight. While many scientists think that skimming and the loss of flight are secondary in stoneflies (similar to the complete loss of flight by penguins), skimming on the water may provide an insight into how primitive wings were used by insects.

Environmental significance

Stoneflies are very sensitive to water quality. The number of species occurring in a particular stream is sometimes used as an important indicator of the stream's health.

Family: Austroperlidae

The genus *Tasmanoperla* is endemic to Tasmania.

Distinguishing characteristics

Austroperlid nymphs can be recognised by the extended corners of their first thoracic segment, a long cylindrical abdomen, short cerci and a small number of gills. The size of mature nymphs varies from 8 to 30 mm.

Possible misidentifications

Acruroperla and *Crypturoperla* nymphs can sometimes be confused with notonemourids. Notonemourids lack dorsal tubercles on the abdomen.

Classification and distribution

This small family includes eight species. Five genera are known from south-eastern Australia: *Acruroperla*, *Austroheptura*, *Austropentura*, *Tasmanoperla* and *Crypturoperla*. *Tasmanoperla* and *Crypturoperla* occur only in Tasmania.

Habitat and ecology

Austroperlid nymphs are often associated with woody debris or can be found in the turbulent waters in the middle of the channels of alpine and semi-alpine streams. They feed on detritus and softened wood.

Natural history

Eggs are laid in autumn and nymphs spend around two years in the water before becoming adults. Most nymphs are rather slow moving.

Most austroperlid nymphs have long cylindrical abdomens, short cerci and a small number of gills.

Family: Eustheniidae

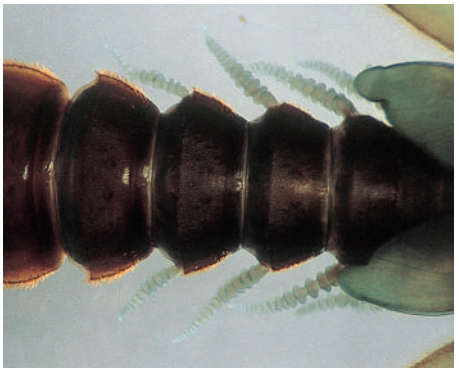
Eustheniids are the largest and most colourful stoneflies in Australia.

Distinguishing characteristics

This family includes the largest and most colourful stoneflies in Australia. The nymphs, which can reach up to 60 mm in length, can be easily recognised by five or six pairs of beaded gills on the sides of their abdomen and long robust cerci.

Possible misidentifications

Eustheniids are very distinctive and are difficult to confuse with any other group.



Eustheniid nymphs have gills on the sides of the abdomen.

Classification and distribution

There are three eustheniid genera in Australia: *Cosmioperla, Eusthenia* and *Thaumatoperla*.

Habitat and ecology

The nymphs are sensitive to low levels of dissolved oxygen. Many taxa require cooler water temperatures and are therefore restricted to fast-flowing alpine creeks with pebble and cobble beds.

The nymphs of all eustheniids are voracious predators and have a pair of sickle-like piercing jaws. They can crawl rapidly under stones in search of their prey, which consists mainly of other aquatic invertebrates, sometimes even including smaller stoneflies.

Natural history

It takes three or four years for eustheniids to complete their lifecycle. This is due to their large size and the alpine temperatures, which slow down the metabolic rate of nymphs. If disturbed, nymphs drop from stones, curl and let the water current carry them away from the danger. They can also swim with fish-like movements by bending the abdomen.

Family: Gripopterygidae

Distinguishing characteristics

All gripopterygids have a gill tuft at the end of their abdomen. Their size ranges from 5 to 30 mm.

Possible misidentifications

A gripopterygid can be confused with a notonemourid if its anal gill tuft is retracted. If you are identifying dead specimens, the gripopterygid's tuft can sometimes be gently squeezed out with forceps. Live gripopterygids will usually have their gills exposed and will often wave them through the water with a dog-like tail wag.

Classification and distribution

These are the most common stoneflies in Australia and Gripopterygidae has the largest number of species in Australia. Genera include: *Kirrama* (only in northern Queensland), *Cardioperla* (only in Tasmania), *Dundundra* (only in northern Queensland), *Nescioperla* (only in northern Queensland) *Leptoperla, Newmanoperla, Riekoperla, Neboissoperla, Illiesoperla, Eunotoperla* and *Trinotoperla*.

Two species of adult gripopterygid are wingless. One is found only on top of Mt Kosciuszko and the other in a small trickle near the top of Mt Donna Buang in Victoria.

Habitat and ecology

Gripopterygids can be found in all kinds of creeks and rivers at any altitude. Some species occupy the middle of the channel while others can be found only at the bank. Some species prefer stones as a habitat, while other live among aquatic plants.

The gripopterygid diet is diverse. Some species eat only detritus or algae from the surface of submerged leaves, wood and rock. Other species switch to a carnivorous diet at a later stage of development.

Gripopterygid adults are a common sight near mountain streams in autumn and spring.

Some species of *Riekoperla* have a dorsal row of spines along the centre of their abdomen.

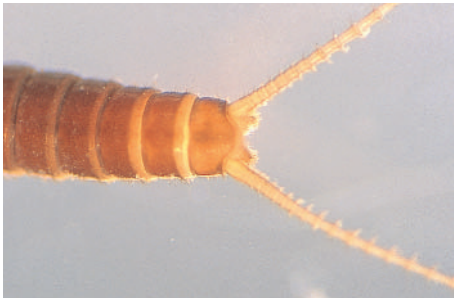
The genus *Leptoperla* has slender nymphs with relatively long legs.

Natural history

The lifecycle of gripopterygids is quite variable. Commonly it takes around one year for a nymph to become an adult. Emergence takes place in autumn and spring.

Family: Notonemouridae

Notonemourid adults are very agile. Some species can jump.



The absence of external gills is a characteristic feature of notonemourid nymphs.

Distinguishing characteristics

Notonemourid nymphs can be recognised by the absence of external gills. Their size ranges from 7 to 12 mm.

Possible misidentifications

See Gripopterygidae.

Classification and distribution

The six genera within the family Notonemouridae are *Notonemoura*, *Austrocercella*, *Austrocerca*, *Austrocercoides*, *Kimminsoperla* and *Tasmanocerca*.

Habitat and ecology

Notonemouridae can be found on rock surfaces and medium-size wood debris in small alpine streams and even trickles. Some species can be collected from the stagnant waters of alpine swamps and pools.

Natural history

Relatively little is known about the lifecycle of Australian notonemourids. They can emerge throughout the year but it is more likely to find adults in late spring, summer and autumn.

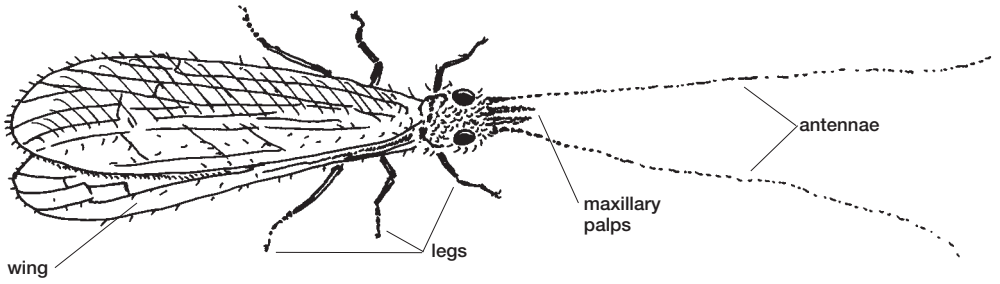
The body of a notonemourid nymph is often densely covered with setae that trap silt and fine sand.

For stoneflies, notonemourids are surprisingly active. They can move quite fast on the surface of rocks. Some species have an enlarged femur of the hind legs, and the adults tend to run and jump rather than fly.

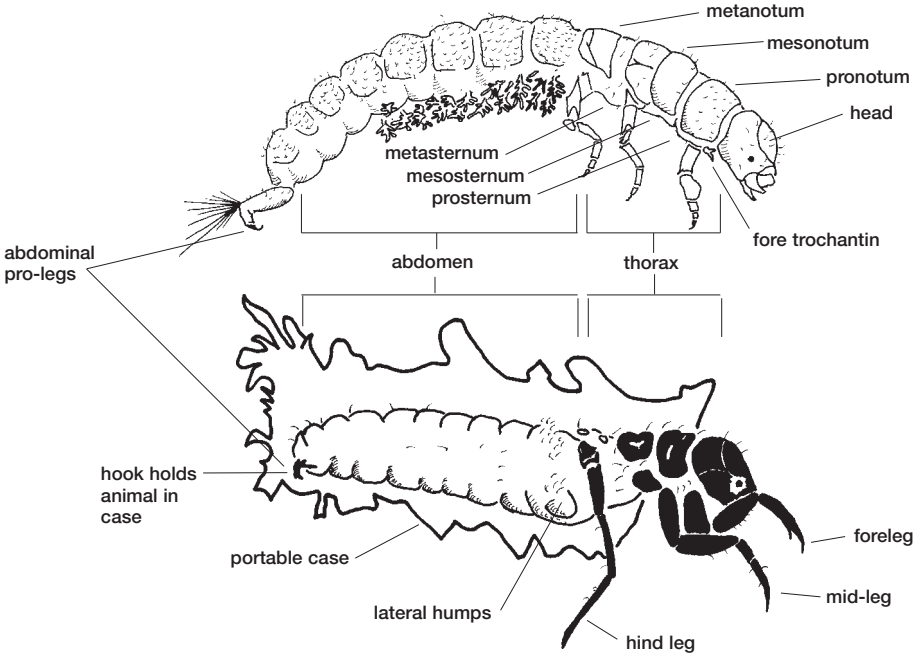
Caddisflies (Order: Trichoptera)

The caddisflies are an extremely diverse group, including some of freshwater's most fearsome predators, as well as docile algal grazers and leaf chewers.

ADULT CADDISFLY



CADDIS LARVAE



An adult leptocerid showing its long antennae and maxillary palps.

A larval hydroptilid caddis has a small pair of hooks at the end of its abdomen to grip the inside of the case.

Characteristics of an adult

Adult caddisflies superficially resemble moths. This is not surprising as they are quite closely related. Unlike moths, however, their wings rarely have scales and are covered with hairs instead. The mouthparts of caddisflies are long, paired and straight instead of long, fused into a tube and coiled, like a moth's. The antennae of many caddisflies are also very long. Adult caddisflies can sometimes be active during the day, but larger numbers are often seen in the evening close to the water bodies where their larvae occur. Most adult caddisflies are attracted to light, and this tendency makes it even more likely that they are mistaken for moths.

Characteristics of a larva

Caddis larvae can be broken into two simple groups: those that live in portable cases (cased caddis), and those that are caseless or free-living. All caddis larvae have the front part of their bodies hardened or sclerotised, while the abdomen remains pale and fleshy. They also have a pair of hooks at the end of their abdomen. Cased caddis larvae use these hooks to hold on to their cases, while free-living larvae use them to grapple the stream bed and drag themselves swiftly backwards to escape from predators. In those families with portable cases, the case protects the soft abdomen of the animal from predators. If attacked or surprised, the caddis larva can withdraw into the case and wait for danger to pass. Free-living caddis larvae lack these portable cases, but can build retreats from thin strands of silk fixed to rocks. Often they will return to these after a day foraging. Some structures incorporate nets for catching food—a bit like a spider's web—while others are mainly used as protection when the animal begins to pupate. Most caddis larvae have silk glands that stretch the length of their body. These are sufficient to constantly repair and rebuild their portable cases or fixed retreats if they are damaged or washed away.

Classification

There are 26 families and around 500 species of caddisfly in Australia. One of these families (Chathamiidae) is marine, and therefore not covered by this book, while the larvae of another family (Stenopsychidae) haven't been recorded yet. Most of the species of Trichoptera found in Australia are endemic, and two families, Plectrotarsidae and Antipodoeciidae, are totally endemic. The families covered in this text are: Antipodoeciidae, Atriplectididae, Calamoceratidae, Calocidae, Conoesucidae, Ecnomidae, Glossosomatidae, Helicophidae, Helicopsychidae, Hydrobiosidae, Hydropsychidae, Hydroptilidae, Kokiriidae, Leptoceridae, Limnephilidae, Odontoceridae, Oeconesidae, Philopotamidae, Philorheithridae, Plectro-

tarsidae, Polycentropodidae and Tasimiidae. The Dipseudopsidae and Psychomiidae have been left out as they are mainly found in tropical Australia.

Carpenters, stonemasons and spinners

Cased caddisfly larvae use a variety of building materials for their homes. Their choice of building materials depends on the speed of the water, the materials available, and the particular preferences of the species of caddisfly. For example, many of the leptocerids live in slow-flowing habitats, where there is a lot of plant matter available, so they tend to construct cases from sticks and aquatic plants. Glossosomatids tend to occur in faster-flowing streams, with gravel and sand, so this is what they use to construct their cases. All caddis larvae use silk to build their cases and some caddises construct cases using only silk. This gives the cases a 'spun' appearance. The silk is spun from an organ on the underside of the head (the labium) and can vary in colour from cream and golden, to dark brown or black.

The caddis larva *Oecetis* (Leptoceridae) uses lengths of water milfoil leaf to construct its log cabin-like case.

Environmental significance

Many caddisfly larvae are quite sensitive to water quality, and for this reason, they are used worldwide to assess river health. However, some leptocerids and hydropsychids can tolerate quite degraded sites, so their presence should not be used as an absolute indicator of 'good' water quality. It is safer to use the presence of a diverse range of caddis larvae as an indicator of stream health.

Glossosomatids cluster together before pupating. They form their cases from hard-wearing sand and gravel which will withstand fast-flowing water and the odd rolling pebble.

Key to families of caddis larvae*

1	abdomen swollen, thicker than thorax; construct a purse-shaped case of silk, sometimes with sand or algae incorporated. . . . . **Hydroptilidae** (p. 201)
1	abdomen not noticeably swollen or thicker than thorax; case if present, not purse-shaped **2**
2(1)	mesonotum and metanotum each with one pair of small sclerites; abdominal pro-legs partially fused and sclerotised; construct a small, dome-shaped sand case incorporating a variety of particle sizes . . . . . **Glossosomatidae** (p. 197)
2	mesonotum and metanotum with more or less sclerotisation than above; pro-legs either totally fused to form a false 10th segment, or totally separate **3**
3(2)	larvae free-living/caseless, or constructing a retreat attached to the substrate; first abdominal segment without lateral/dorsal humps; well-developed abdominal pro-legs with conspicuous claws **4**
3	larvae usually found inside a portable case **8**
4(3)	all three thoracic segments with sclerotisation **5**
4	only the first thoracic segment with sclerotisation **6**
5(4)	abdominal gills present . . . . . **Hydropsychidae** (p. 200)
5	abdominal gills absent . . . . . **Ecnomidae** (p. 196)
6(4)	labrum membranous and pale, front edge wider than back . . . . . **Philopotamidae** (p. 207)
6	labrum sclerotised and with front edge similar or less wide than back **7**
7(6)	foreleg modified, either with pincers, or with the femur broadened and armed with thick spines; fore trochantin small . . . . . **Hydrobiosidae** (p. 198)
7	foreleg simple without pincers and with femur not broadened; fore trochantin large . . . . . **Polycentropodidae** (p. 210)
8(3)	larvae construct a coiled case of sand grains superficially resembling a snail shell; claws on abdominal pro-legs modified to form a comb-like structure . . . . . **Helichopsychidae** (p. 198)
8	larval case uncoiled, claws on abdominal pro-legs usually unmodified **9**
9(8)	head long and very small relative to thorax, thin and without visible joins; pronotum with two pairs of sclerites on anterior half, posterior half without sclerites and retractable into mesonotum . . . . . **Atriplectididae** (p. 192)
9	head not reduced, broad with visible joins: pronotum completely sclerotised **10**
10(9)	middle leg with tibia and tarsus fused **11**
10	middle leg with tibia and tarsus not fused **12**
11(10)	foreleg with tibia and tarsus fused; two main sclerites on the underside of the head completely separated . . . . . **Kokiriidae** (p. 202)
11	foreleg with tibia and tarsus not fused; two main sclerites on the underside of head not completely separated . . . . . **Philorheithridae** (p. 208)
12(11)	prosternum with a single thick, curved, horn-like spine **13**
12	prosternum without thick, curved, horn-like spine **14**
13(12)	mesonotum with three pairs of sclerites; underside of first abdominal segment with three pairs of setae . . . . . **Plectrotarsidae** (p. 210)
13	mesonotum with a single large sclerite; underside of first abdominal segment with more than three pairs of setae . . . . . **Limnephilidae** (p. 205)

Key to families of caddis larvae (contd.)

14(12) metasternum with two or more setae **15**
14 metasternum without setae **16**

15(14) antennae often long; pronotum usually with few setae on the anterior; if numerous setae, then also with sclerites on the metasternum ..... **Leptoceridae** (p. 203)
15 antennae minute; pronotum with a collar of setae; metasternum with setae but never with sclerites ..... **Calocidae/Helicophidae** (p. 194)

16(14) abdomen with a conspicuous fringe of fine setae **17**
16 abdomen without a conspicuous fringe of fine setae **19**

17(16) head capsule with a prominent ridge (carina) around the edge of the dorsal side ..... **Oeconesidae** (p. 207)
17 head without a prominent ridge around the edge of the dorsal side. **18**

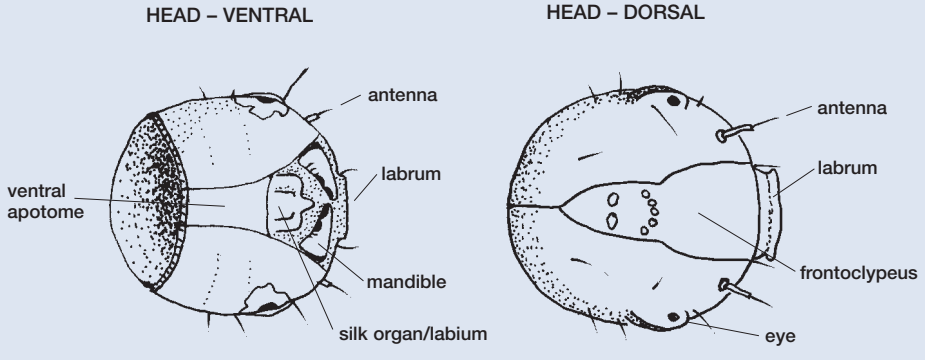
18(17) case built from sand/gravel; hind legs and forelegs of similar size; eyes protruding when viewed dorsally ..... **Tasimiidae** (p. 211)
18 case built from two pieces of leaf; hind legs about twice the length of the forelegs ..... **Calamoceratidae** (p. 193)

19(16) prosternum with large sclerite or sclerites ..... **Odontoceridae** (p. 206)
19 prosternum pale and membranous **20**

20(19) underside of head capsule has the two major plates (sclerites) separated posteriorly; the sclerite between these is usually square or rectangular ..... **Conoesucidae** (p. 195)
20 underside of head capsule with the two major plates almost touching posteriorly, and with the plates between them triangular in shape **21**

21(20) pronotum with a sharp, blade-like collar ..... **Antipodoeciidae** (p. 192)
21 pronotum without a sharp, blade-like collar ..... **Calocidae/Helicophidae** (p. 194)

*modified from Dean, St. Clair and Cartwright 1995



Family: Antipodoeciidae

Distinguishing characteristics

The larvae of this caddis have a distinctive blade-like ridge along each side of the pronotum. The ridge is also generally knobbly or beaded. They are about 5 mm long and construct a small case from sand.

Possible misidentifications

Antipodoeciids are relatively rare, so many questionable identifications may in fact be Calocidae/Helicophidae or Conoesucidae.

Classification and distribution

This small family includes only one species in the genus *Antipodoecia*. It is relatively rare and occurs only on the east coast of mainland Australia.

Antipodoecia sp. shows the distinctly beaded carina on its pronotum.

Habitat and ecology

Very little is known about this group, but larvae seem to occur in small streams with fairly good water quality.

Vulture caddis (Family: Atriplectididae)

Distinguishing characteristics

These larvae can be fairly large (8–18 mm). They can be distinguished by their cases which are constructed from sand and finer sediments and are almost square in cross-section with a groove along the length of the upper surface. The larvae themselves have distinctly elongate heads, which appear seamless and are retractable into the thorax. Adults from this family have very long antennae, and look a bit like adult leptocerids, but are less common.

Possible misidentifications

Atriplectidids are very distinctive and therefore difficult to misidentify.

Classification and distribution

Atriplectides dubius is the only recognised species of Atriplectididae in temperate Australia. It occurs quite commonly along the east coast of mainland Australia and

The groove on the upper surface of larval atriplectidid cases is distinctive, but its function is uncertain. Both the legs and head of *Atriplectides* are specialised for feeding on dead invertebrates.

Tasmania. This family is also found in the Seychelles Islands and South America.

Habitat and ecology

Atriplectides occurs quite commonly in coastal areas. Caddises from the family Atriplectididae are scavengers that fossick around in slow waters and silty habitats where they feed on decaying animal and plant material.

Natural history

Atriplectides' strange head shape allows it to scavenge the bodies of other dead animals. Once it has made a large enough hole for its head, it can get to the soft flesh inside a carcass without wasting effort on cutting through any more of the leathery skin. This is a similar tactic to that used by vultures.

Sleeping bag caddis (Family: Calamoceratidae)

Distinguishing characteristics

Both the larvae and the cases of this family are quite distinctive. The cases are made from two leaf fragments, the dorsal leaf being slightly larger than the ventral. Cases can be as long as 20 mm and are usually fairly wide, but distinctly flattened. The larva has a fringe of hairs around the edge of its abdomen, and its hind legs are around twice the length of its forelegs. The pronotum is also distinctive when viewed dorsally, with recurved sides.

Adult calamoceratids often have simple but eye-catching patterns on their wings.

Possible misidentifications

Although the cases are quite distinctive, some leptocerids (*Lectrides* and *Westriplectes*) build a similar case, so inspect the larvae themselves for an accurate identification.

Classification and distribution

Anisocentropus is the only calamoceratid genus found in Australia. The family occurs in other parts of the world, including the northern hemisphere. Ten species occur in Australia, and three of these in south-eastern Australia, but they cannot be distinguished from one another as larvae. Both larvae and adults are quite common.

Habitat and ecology

Calamoceratids feed on decaying plant material and are usually found in still sections of slow-flowing lowland rivers, swamps and lakes.

The overlapping leaves in the calamoceratid's case obscure the animal's head from predators. From above it resembles a slow moving leaf.

Natural history

The wings of adult calamoceratids are often decorated with highly contrasting patterns. This distinguishes them from most other caddisflies, which normally sport muted grey colours and softer patterns.

Families: Calocidae/Helicophidae

Caenota plicata is a very common and widespread calocid. Its 'shingle' case pops up in a variety of streams. The collar of long hairs on the front edge of the pronotum is a character shared by many calocids and helicophids.

Distinguishing characteristics

The larvae from this pair of families vary in size (6–14mm) and appearance. They construct a wide range of case types using either plant matter, sand, silk, or all of these. Their distinguishing characteristics are quite subtle, and include minute antennae, a triangular ventral apotome (often unpigmented in the posterior half), a fully but weakly sclerotised mesonotum, and a metanotum with hairs but very little sclerotisation. Several genera have a distinctive fringe of long dark hairs around the front edge of the pronotum, but this does not hold true for the entire group.

Possible misidentifications

Calocid/helicophid larvae can easily be confused with a range of other caddis families, especially when earlier instars are being identified.

Classification and distribution

These two families are represented in Australia by around 15 described genera. All but one of these is found in south-eastern Australia. The families also occur in New Zealand and South America.

Habitat and ecology

The larvae of the more common species can be found in the slower sections of clear, swift-moving streams in forested areas. They often live around areas that accumulate decaying plant matter. Two species have been recorded from terrestrial habitats in Tasmanian rainforests. The Calocidae and Helicophidae are thought to feed on decaying plant material and micro-algae.

Natural history

These two families include a wide range of species that can be found in a diverse range

Many of the calocids and helicophids have orange head capsules like this example from the genus *Tamasia*.

Caddis from the genus *Alloecella* often have a distinctive cowl at the front of their case.

of habitats, from small alpine swamps, to medium-sized, forested streams. They are usually associated with good water quality. Some of the most magnificent cases amongst caddis larvae belong to members of this group, including the extremely long silk and sand structures of *Alloecella*, some of which have a cowl to protect the animals head while it moves around.

Family: Conoesucidae

Distinguishing characteristics

The head of larval conoesucids is round when viewed from above. The two major plates on the ventral side of the head are well separated posteriorly, and the sclerite between them is rectangular. The antennae are found very close to the front of the head. Cases are roughly cylindrical, but can be constructed from a variety of materials. The cases of several genera are very distinctive, but these designs are not consistent across the whole family. The members of this family vary in size, some of the squat species can be around 5 mm long, but most reach about twice this length.

Possible misidentifications

Conoesucid larvae superficially resemble calocid/helicophid larvae, and to a lesser extent, the antipodoeciids. Mistakes can be avoided by paying close attention to the ventral surface of the head. Conoesucids have the major plates of the ventral surface well separated by a square sclerite—the ventral apotome.

Classification and distribution

In south-eastern Australia there are six described genera with 21 species. This family is also found in New Zealand.

Some conoesucid caddis such as this *Conoesucus* sp. have an impressive hoop basket case.

Habitat and ecology

Conoesucids are common in small- to medium-sized streams across a variety of water speeds, but rarely in very fast water. They can also be found in cold lakes. They are thought to feed on a combination of decaying plant matter and benthic algae.

Natural history

Conoesucid cases are some of the most attractive structures found in streams. *Conoesucus* builds a case from bent hoops of plant matter, giving it a basket-like exterior, while *Lingora*, *Hampa* and *Matasia* all build cases from rows of sand grains and fine gravel. The genus *Costora* can build either of these designs (depending upon the species). It may also construct cases from layers of silk.

Conoesucids are quite a variable-looking group. The stout caddis is *Lingora* sp. (top), and the slender golden case (bottom) contains *Costora delora*. The latter's case is made entirely of silk.

Family: Ecnomidae

Distinguishing characteristics

Ecnomids are free-living or caseless caddis that grow to around 15 mm long. All thoracic segments are dorsally sclerotised, although the larva may have a gap down the middle of its mesonotum and metanotum (as with the genus *Ecnomina*). Many of the species from the genus *Ecnomus* have a distinctive black and cream head pattern, while *Ecnomina*'s head is usually orange or brown. Abdominal pro-legs are well developed and the abdominal segments lack gills.

Possible misidentifications

Very early instars of some hydropsychids may lack abdominal gills, and this will make them key to ecnomids. It is safer to leave very early instars (<1.5 mm) unidentified.

Classification and distribution

Two genera, *Ecnomina* and *Ecnomus,* occur in Australia, with more than 30 species in

Caddis larvae from the genus *Ecnomus* have a detailed head pattern that is often species specific. *Ecnomina*, the other genus found in Australia has a plain brown or orange head.

temperate Australia. The family Ecnomidae is found almost worldwide but is missing from the colder parts of North America.

Habitat and ecology

Ecnomids live in lakes and slow-moving streams, where they construct simple silk retreats on rocks and logs. They are roving predators and can sometimes be seen hunting or collecting detritus on the surface of fine sediment deposits in low flow areas. Young larvae start life as detritivores.

Glossos (Family: Glossosomatidae)

The cases of *Agapetus* (Glossosomatidae) vary a lot depending on the gravel or sand that is available.

Glossosomatid cases are open at both ends, allowing their occupants to reverse out of trouble.

Distinguishing characteristics

The cases of larval glossosomatids are often referred to as saddle-cases due to their humped shape. The ventral side of these cases is often flatter than the dorsal and constructed from a finer grain of sand or stone. They are small- to medium-sized caddis, most temperate species growing to about 6 mm. The larvae have partially sclerotised abdominal pro-legs with a distinctive flat-bottomed 'U' shape when viewed end on. The pronotum narrows towards the front when viewed from above, and the mesonotum and metanotum each sport a pair of small sclerites.

Classification and distribution

The family Glossosomatidae occurs worldwide and is represented in Australia by a single genus, *Agapetus*.

Habitat and ecology

Glossosomatids occur in medium- to fast-flowing water that is cool and well oxygenated. They are typically found amongst large rock substrates, where they feed on benthic algae and other fine organic material.

Natural history

The larval cases of *Agapetus* can be found in aggregations at the edges of streams once the larvae have begun to pupate. Before pupation, the larvae crawl to near the surface, cut the base out of their cases, and stick them to stable parts of the stream bed. Larval glossosomatid cases are interesting because they are symmetrical, and have two openings. The larva can turn around inside the case, and face in either direction.

Snail-shelled caddis (Family: Helicopsychidae)

Helicopsyche murrumba is a slow-moving algae/detritus eater.

The name Helicopsychidae refers to the helical, or round and twisted shape of this caddis' case.

Distinguishing characteristics

Helicopsychid larval cases look like small snail shells (<6 mm) made from sand grains. They are rarely separated from their cases, so this characteristic will normally be sufficient for identification.

Possible misidentifications

Larvae that have been separated from their cases might look a bit like members of the Calocidae/Helicophidae, or Conoesucidae, but they have a curved body, as a result of their lives inside their coiled cases.

Classification and distribution

Helicopsychids are found worldwide, and represented by a single genus, *Helicopsyche,* in Australia. Ten species are recorded for south-eastern Australia.

Habitat and ecology

Helicopsychids are typically found in cool streams with moderate- to fast-flowing waters, although some species may occur in warmer waters, and sometimes lakes. They graze benthic algae from pebbles and larger grades of stone.

Natural history

All helicopsychid cases have a clockwise spiral when viewed from above. Even helicopsychids in the northern hemisphere spiral in the same direction—regardless of the way water spirals down the kitchen sink!

Family: Hydrobiosidae

Distinguishing characteristics

This is one of the more common families of caseless caddis. The front legs of all hydrobiosids are modified in some way, either with pincers, or with elongate claws. The pronotum is always sclerotised and the ninth abdominal segment is usually dorsally sclerotised, while the mesonotum and metanotum are always membranous. The abdominal pro-legs are distinctly separate and each bears a large sclerite on the outer surface. Hydrobiosids often have brightly coloured bodies, and come in pink, green, yellow and sometimes blue. They can grow to around 15 mm.

Possible misidentifications

Hydrobiosids may be confused with philopotamids, but philopotamids never have modified front legs.

Classification and distribution

Fifteen genera of Hydrobiosidae are recognised in south-eastern Australia.

Habitat and ecology

Hydrobiosids are usually found in cool, clear, fast-flowing streams, and more rarely in slightly warmer waters. All hydrobiosids are predatory. They use their modified forelegs to capture, disable and rip apart their prey.

Natural history

Hydrobiosids use very little silk compared to other caddis larvae. They use silk threads as a safety line while they forage around cobbles and then shortly before they pupate, they construct a retreat from sand and small stones. Once inside, the larva spins a fine silk pupal case that resembles a vitamin capsule. The larva/pupa is clearly visible through the sides of this inner case.

All the hydrobiosids have robust hooks on their abdominal pro-legs, and these allow them to make a quick getaway when confronted by opponents or larger predators.

Apsilochorema has its forelegs modified into a ferocious hook and a muscular femur.

Ethochorema has scissor-like modifications to its forelegs that are effective for holding prey.

Ulmerochorema has an ecnomid-like head pattern, but only its pronotum is sclerotised.

Like all the hydrobiosids, *Taschorema* has robust hooks on its abdominal pro-legs.

Net spinning caddis (Family: Hydropsychidae)

Distinguishing characteristics

Hydropsychid larvae have obvious filamentous gills on the ventral surface of their abdomen, all three thoracic segments sclerotised, and well-developed abdominal pro-legs with claws. They construct fixed retreats from a variety of materials stuck together with silk. These retreats tend to be tubes equipped with a net at one end. Larvae rarely exceed 12 mm in length. Some adults have white wings, often with dark patterns on them, and are referred to as snowflake caddis.

Adult hydropychids are usually white: this has earned them the nickname 'snowflake caddis'.

Possible misidentifications

See Ecnomidae.

Classification and distribution

The family Hydropsychidae occurs worldwide. Six genera occur in temperate Australia. They are common in streams in south-eastern Australia, and can occur in large numbers.

Habitat and ecology

Hydropsychids are found in moving water, in a wide range of streams, on rocks and large woody debris. They are omnivorous, feeding on small animals and plant material caught in their nets.

Cheumatopsyche has its abdomen lined with gills so that it can remove enough oxygen from the still waters within its silken retreat.

Net spinning caddis larvae spend a lot of time in the lean-to attached to the side of their net.

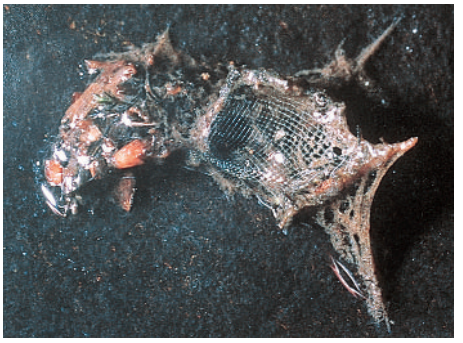
Net builders

Some of the free-living hydropsychid larvae use silk to construct nets which trap smaller animals and detritus that are drifting in the current. These nets are sticky and can be held in shape by struts of vegetation, and gravel. Often the nets are built onto the front of a silken retreat. Net builders usually occur in flowing waters.

Natural history

Hydropsychids have been well studied in the northern hemisphere. A great deal is known about the nets they build and how different net structures and sizes are used by different species to capture different types of food. These net structures seem to vary, depending upon the speed of the water in the river.

Hydropsychid larvae are thought to be territorial, defending a small area around their nets from other hydropsychids. Some hydropsychid genera have a series of fine grooves on the underside of their heads, which they rub with their forelegs to make stridulations. These are a series of noises (a bit like those made by cicadas and crickets) that are thought to warn off other hydropsychids that might compete for net space.



A *Cheumatopsyche* net, with a retreat made from vegetation and silk to its left.

Microcaddis (Family: Hydroptilidae)

Distinguishing characteristics

Hydroptilids are all very small (<5 mm). Their cases are commonly referred to as 'purse-shaped', but in some genera they may resemble wheat seeds. These portable cases are constructed from silk alone, or a combination of silk, algae and sometimes fine sand. The larvae themselves have all thoracic segments sclerotised, and these segments are quite thin. In comparison, the abdominal segments are swollen and the final segment bears sclerites and hooks. Very early instars have sclerites on many of their abdominal segments and are covered in long hairs.

Classification and distribution

The Hydroptilidae is a large and very diverse family with a worldwide distribution. Ten genera are present in temperate Australia. Hydroptilids are very common but can be overlooked because of their small size.

Habitat and ecology

Hydroptilids can be found in a variety of habitats. Some species occur amongst water plants, while others prefer pebbles and cobbles. Their cases are quite resilient, so it is quite common to find large numbers of empty cases stuck to surfaces in streams, left there by previous generations. Most genera are thought to eat algae (filamentous, or benthic), but some have been recorded feeding on the eggs of other invertebrates. Some microcaddis (from the genus *Orthotrichia*) are parasitic on pupae from the caddis families Hydropsychidae and Philopotamidae.

Microcaddis from the genus *Hellyethira* can be quite common, but their small size makes them difficult to spot.

Natural history

Hydroptilids are known mainly from their final instars, which construct a case. The earlier instars are very small, highly sclerotised, and covered with long hairs. These hairs are thought to allow them to drift in the water where they feed on plankton and fine organic matter. The later instars construct a case and eventually attach it to a solid surface shortly before pupating. The adult caddisflies can sometimes be seen near streams where they form clouds of animals, mating and preparing to lay eggs. The adults are also very small (4–12 mm) and the numerous fine hairs on their wings give them a frosty, opaque appearance when in flight.

Most microcaddis, like this *Hydroptila* feed on algae.

Family: Kokiriidae

Distinguishing characteristics

Kokiriids vary in size and build a variety of portable cases. Some are made from sand and small stones and are quite distinctively shaped, the dorsal surface projecting over the front and sides. Other cases are less distinctive, being flat and made of detritus.

Taskiria otwayensis demonstrates the impressive blades formed by fused tibia and tarsi in members of the Kokiriidae.

The larvae have weak sclerotisation on the mesonotum and metanotum, and the abdomens have gills and a lateral fringe of short, fine hairs. The most distinctive feature is the fusion of the tibia and tarsi on both the fore and mid-legs to create two sets of blades to dispatch prey.

Possible misidentifications

Young philorheithrids (and sometimes even leptocerids) have pale mid-legs in which the segmentation is difficult to see. Kokiriids are fairly rare, so dubious identifications are likely to be from these two groups.

Classification and distribution

The family Kokiriidae is found only in Australia, New Zealand and South America. Three genera are recorded from south-eastern Australia.

Habitat and ecology

Kokiriid larvae occur in sandy-bottomed streams or small seeps, but they are quite rare even in streams where they have previously been recorded. Their fore- and mid-legs are both simplified to form sharp piercing blades, which they use to kill prey.

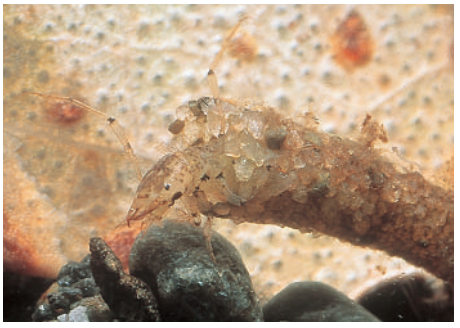
Stick caddis (Family: Leptoceridae)

Distinguishing characteristics

The Leptoceridae is one of the commonest families in temperate Australia. They construct a variety of cases, usually from wood or finer plant matter, although they may sometimes incorporate sand and small stones. The pronotum and mesonotum are strongly sclerotised, but the metanotum is less so, sometimes without sclerites, but often with two to five sclerites on an otherwise membranous segment. The metasternum has two or more hairs, and the antennae are often long and prominent. The hind legs of leptocerids are usually long, often twice the length of the forelegs, and the femur is divided. The tibia and tarsus of the mid-legs is also divided in some genera. Size is very variable for the larvae of this family (2–20 mm). Adult leptocerids have very long antennae, usually between one–and-a-half to twice the length of the wings. The antennae droop below the animal when it flies.

Possible misidentifications

Some leptocerids (for example *Triplectides*) have small antennae, and can superficially resemble the Calocidae/Helicophidae. These animals can only be properly separated using the combination of



The spotty-headed *Oecetis* is another common leptocerid genus. It builds a variety of cases and is found in most habitats.

Adult leptocerids have exceptionally long antennae, a character that they share with the less common atriplectidids.

Notalina spira is a common leptocerid. It has a distinctively striped head and will often move around by thrashing its body back and forth.

Symphitoneuria opposita is found in slightly saline waters. Its case is weighted with sand at the front and always falls opening first.

Triplectides is one of the commonest and most pollution-tolerant genera of the Leptoceridae. It is also the only genus to hollow out sticks and use them as cases.

chacteristics outlined in the key on page 191. Larvae in flat cases (*Lectrides* sp. and *Westriplectes* sp.) are often confused with Calamoceratidae. Aquatic caterpillars can build a vegetation case but they have simple legs that are all roughly the same length, rather than long hind legs like a caddis.

Classification and distribution

The Leptoceridae is distributed worldwide, and is extremely diverse. Fifteen genera and more than 70 species occur in temperate Australia. Multiple species are frequently recorded from fairly small sections of habitat.

Habitat and ecology

Leptocerids occur in a wide range of habitats, from upland streams to temporary ponds and often are the only caddises in saline waters. They are restricted within these areas to slower-flowing patches, where organic matter accumulates. Leptocerids are thought to be omnivorous and the common genera, *Triplectides* and *Notalina,* are often found shredding live and dead plant material. Some, such as the spotty headed *Oecetis*, may be predatory.

Natural history

Leptocerids are possibly the most common caddis encountered. Some (*Triplectides*) construct their cases from sticks and bits of wood, which they hollow out and line with silk. This case design is quite cryptic, and it can make finding these larvae quite difficult. Their size (>10 mm) and their lurching movement will eventually give them away. Occasionally leptocerids have been observed with two larvae housed in opposite ends of the same piece of wood.

Family: Limnephilidae

Distinguishing characteristics

Limnephilid larvae construct a large, untidy case from either gravel or plant matter. They grow to around 25 mm, have abdominal gills, and a fringe of hair along the sides of their abdominal segments. The prosternum has a ventral horn between the forelegs, which can be difficult to see. The metanotum has two or three pairs of small sclerites. The mesonotum has a single large sclerite and the underside of the first abdominal segment has more than three pairs of hairs.

Possible misidentifications

Plectrotarsids may appear similar, but they have three pairs of sclerites on the mesonotum, rather than a single sclerite .

Classification and distribution

The family Limnephilidae occurs worldwide and they are possibly the most diverse caddis in North America, with more than 50 genera. One genus, *Archaeophylax*, with three species, is found only in south-eastern Australia.

Habitat and ecology

Limnephilids are found in a variety of habitats, ranging from cool mountain streams, to ponds. Despite their broad range they are most abundant in alpine areas. Most limnephilid larvae were thought to feed on fine organic matter but one species, *Archaeophylax canarus,* can be an opportunistic carnivore, capable of dispatching prey around half its size.

Archaeophylax canarus devours a leptocerid. Despite their robust looks limnephilids are likely to be opportunistic carnivores rather than active hunters.

Limnephilids, like this bottled *Archaeophylax ochreus,* are some of the largest caddis found in Australia.

Family: Odontoceridae

Distinguishing characteristics

The Odontoceridae is a difficult group to define because of the differences between the various species within the family. They all have comparatively long anal claws and their legs have femurs that are not wider than other leg segments. The pronotum and mesonotum are heavily sclerotised, while the metanotum has two to four sclerites. Their cases are tubular, slightly curved and made from sand and small stones. Fully grown larvae can be as long as 15 mm.

Possible misidentifications

Odontocerid and philorheithrid larvae are very similar. Young philorheithrid larvae do not have the tibia and tarsus of their mid-leg fused and are extremely difficult to distinguish from odontocerid larvae.

Classification and distribution

Two genera occur in south-eastern Australia. This is not a commonly encountered family.

Habitat and ecology

Odontocerids occur in cool clear streams, sometimes in backwaters, where they are probably shredders or scrapers (as they are in the northern hemisphere), but can be opportunistic scavengers.

Marilia fusca is probably an opportunistic predator. It has been observed actively hunting but is also known to feed on detritus.

Natural history

Northern hemisphere examples from this family build cases with silk and mud mortar between the individual stones, and this is thought to make them more robust and resistant to crushing. These cases are well suited to fast-flowing streams, where cobbles and pebbles often wash loose and roll around.

The name Odontoceridae refers to the tooth-like shape of the sand grain cases. In Greek, *odontos* = tooth, and *ceras* or *keration* = horn.

Barynema (left) and *Marilia bola* (right) provide examples of the range of case and body shapes within the family Odontoceridae. *Barynema* is from faster-flowing waters.

Family: Oeconesidae

Distinguishing characteristics

Oeconesids have a very circular head when viewed from above, flat with a prominent ridge around the posterior and lateral edges. The antennae are small and close to the eye, and the pronotum has a constriction across the middle, which forms two bulges. The mesonotum and metanotum both have three pairs of sclerites. The abdominal segments have gills and a lateral fringe. Cases are made from a variety of plant matter, sometimes including moss. Larvae can be quite large, growing to 14 mm.

Possible misidentifications

Oeconesids superficially resemble conoesucids, but conoesucids lack a fringe of hairs along the edges of the abdomen.

Classification and distribution

Oeconesids occur more commonly in New Zealand but are absent from the rest of the world. One species, *Tascuna,* is recorded from south-west Tasmania.

Tascuna is a rare and strange-looking caddis from south-western Tasmania.

Habitat and ecology

Oeconesids have been recorded from a small number of fast-flowing streams in well-forested areas. They eat decaying plant matter.

Family: Philopotamidae

Distinguishing characteristics

Philopotamids construct simple, silk-lined retreats on the undersides of rocks. They spend some time in these, and some time roaming free. The head and pronotum are sclerotised, while the mesonotum and metanotum remain membranous. The most characteristic feature is the membranous labrum, which is 'T' shaped and white against the orange of the head capsule. Live specimens have white or cream bodies and orange heads, and grow to around 10 mm.

Possible misidentifications

Hydrobiosids and polycentropodids also have only the pronotum sclerotised and

Philopotamids have a fleshy white labrum, which sits just above the mandibles. This is probably used while cleaning detritus from their nets.

philopotamids with an indistinct labrum may key to hydrobiosids or polycentropodids. Philopotamids never have modified forelegs (like hydrobiosids), or well-developed fore trochanters (like polycentropodids).

Classification and distribution

Two genera of philopotamid, *Chimarra* and *Hydrobiosella*, with 15 species, occur in temperate Australia.

Habitat and ecology

The philopotamids are found on and under coarser sediments in fast-flowing streams and rivers. They eat algae and other fine organic particles.

Natural history

Philopotamids use their 'T' shaped labrum to remove fine organic particles from the sack-like nets that they construct on the undersides of rocks. The brush is similar in structure (and possibly function) to the vacuum cleaner accessory that you use to clean curtains and upholstery.

Philopotamidae translates from the Greek as river lover (*philos* = lover of, *potamos* = river). Many of the first caddis families to be named were given very general and rather unimaginative names, as the full diversity of the group was unknown at that stage (see Philorheithridae). After 1750, the naming of taxa became more interesting as people like the Swedish naturalist Linnaeus began to relentlessly catalogue things.

Philopotamids often have bright orange sclerotised parts with dark edges.

Family: Philorheithridae

Distinguishing characteristics

Philorheithrid cases are made from sand or small stones, and are stout and sometimes slightly curved. The larvae are large (8–15 mm), with sclerites on all thoracic segments. The prosternum has a large sclerite, as does the dorsal surface of abdominal segment nine. Their most distinguishing feature is the fused tibia and tarsus of the mid-leg which functions as a 'blade' for killing and grasping prey. Some adult philorheithrids are quite distinctive in the way that they roll their wings into a tube.

Tasmanthrus is one of the faster philorheithrids. It moves along using its back two sets of legs, leaving its forelegs free to grab prey.

Adult philorheithrids can be recognised by their posture, and by the way they roll their wings when resting.

Possible misidentifications

Odontocerid and philorheithrid larvae are very similar. Young philorheithrid larvae do not have the tibia and tarsus of their mid-leg fused and are therefore extremely difficult to distinguish from small odontocerid larvae.

Classification and distribution

Six philorheithrid genera occur in temperate Australia (including undescribed ones).

Habitat and ecology

Philorheithrids occur in cool lakes and fast-flowing streams among pebbles and larger rocks. They are fast-moving predators.

Natural history

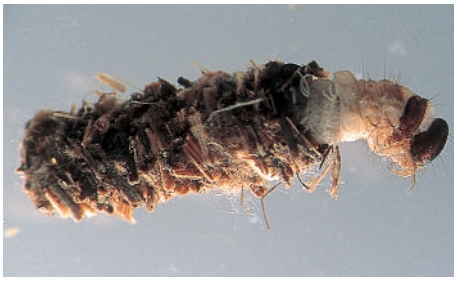
The philorheithrids are fast-moving animals despite their heavy cases. They can stalk, and run down prey almost as big as they are. Common victims include mayfly nymphs, worms, and other caddis larvae. The name Philorheithridae translates from the Greek as stream lover (*philos*= lover of, *rheithron* = a stream channel).

Kosrheithrus demonstrates the formidable sword-like legs that make philorheithrids such efficient predators. The heavy case helps keep this caddis from being swept away when all its legs are stuck in some unfortunate prey.

Family: Plectrotarsidae

Distinguishing characteristics

Plectrotarsids construct untidy cases from plant matter. Their pronotum has a constriction that divides it into two prominent bulges. The prosternum has a small horn-shaped projection. The mesonotum and metanotum each have three small sclerites; the ones on the metanotum are greatly reduced. These animals are stout, with short legs (for a caddis) and grow to around 12 mm.



The rare *Plectrotarsus* can be recognised by its messy case and the constriction on its pronotum.

Classification and distribution

Three genera are recorded from Australia as adults; the larvae are known for only two of these genera. This family is endemic to temperate Australia.

Habitat and ecology

The plectrotarsids occur in slow-flowing waters and swamps amongst large amounts of plant matter. They are probably shredders, though this is assumed from their association with collections of plant matter in streams.

Natural history

Plectrotarsidae has the somewhat dubious honour of being the first caddisfly recorded from Australia. They are also possibly one of the first macroinvertebrates to respond to human impacts in Australia. They were found in 1848 and taken back to Austria for identification. The original accounts describe them as being common in coastal areas south-east of Melbourne, but they have now disappeared, along with the 'chain of ponds' style of stream in which they used to live. These days they are rare.

Family: Polycentropodidae

Distinguishing characteristics

Polycentropodid larvae construct a fixed retreat consisting of a delicate sheet of silk that covers a depression in a rock or piece of woody debris. Larvae have a sclerotised pronotum but their mesonotum and metanotum are membranous. The fore trochanters of these animals are well developed and form a blade-like projection above the forelegs. The abdominal pro-legs are well developed and armed with claws. These larvae rarely exceed 15 mm.

Plectrocnemia, a polycentropodid, looks superficially like a philopotamid, but has a spotty head and a sclerotised labrum

Possible misidentifications

Polycentropodids superficially resemble both the philopotamids and hydrobiosids, however their forelegs are never modified like hydrobiosids, and they lack the T-shaped labrum of philopotamids.

Classification and distribution

Eight genera of Polycentropodidae are found in temperate Australia. The family occurs worldwide.

Habitat and ecology

Polycentropodids occur in slow-flowing streams, on rocks and woody debris. Their feeding habits vary greatly: they have been recorded as filter feeders, shredders and predators. The commoner genera appear to be predatory. They spend much of their time skulking in a retreat, which is connected to a fine network of silk strands.

Paranyctiophylax guards its retreat and the surrounding tripwires vigilantly. Its name translates roughly as 'almost a night watchman'.

When prey blunder into these strands, the larva springs from hiding and eats them. The whole set-up is a bit like a messy, underwater spider web.

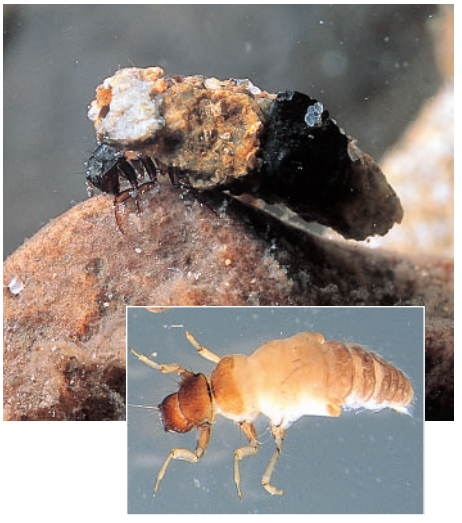
Family: Tasimiidae

Distinguishing characteristics

The tasimiids are medium-sized caddis larvae (5–8 mm) that construct cases from sand or small stones. The dorsal surface overhangs the opening of the case, and the whole structure is slightly dorso-ventrally flattened. The larvae have a rounded head with bulging eyes. The pronotum and mesonotum are both sclerotised, while the metanotum has two pairs of small round sclerites. The first abdominal segment has a pair of lateral humps that are covered with microscopic hooks. The abdomen has a fringe of hairs and lots of gills.

Possible misidentifications

These animals can superficially resemble glossosomatids (from their cases), but tasimiids have the mesonotum fully sclerotised and their cases taper at one end, while the glossosomatids have symmetrical cases.



Tasimia has two prominent lateral humps hidden within its chunky case. These possibly help the animal scale steep rocks, or creep forward in fast flows.

Several generations of empty tasimiid cases cluster along the shoreline of a small stream. This prime pupal real estate allows the newly emerging caddis adults to step out onto land without getting their feet wet.

Classification and distribution

Two genera, *Tasimia* and *Tasiagma,* with six species are known from south-eastern Australia and the family is found only in Australia and South America. They can occur in large numbers in fairly localised patches. This family is restricted to south-eastern Australia.

Habitat and ecology

These animals are usually found in cold, swift streams. Tasimiid larvae graze on benthic algae, and fine organic particles. (They can sometimes be seen cleaning the algae from their stone cases.)

Natural history

The lateral humps on the first abdominal segment of tasimiids can be used to assist the legs of the animal when it is moving through fast-flowing water. The animal pulls itself partially out of its case, and uses the rings of hooks to stick to rocks. Black fly larvae (Diptera) employ a similar structure and coat the rock with silk before attaching themselves to it with a ring of hooks. It is probable that tasimiids are employing a similar method. Tasimiids crawl up the sides of the stream bank before pupating and fix their cases just under the surface of the water. Huge collections of these cases can accumulate over time, with several years worth of pupal cases layered on top of one another.

Listing of SIGNAL grades

Higher taxa	
Acarina	6
Amphipoda	3
Anaspidacea	6
Anostraca	1
Bivalvia	3
Branchiura	1
Bryozoa	4
Coleoptera	5
Collembola	1
Conchostraca	1
Decapoda	4
Diplopoda	4
Diptera	3
Ephemeroptera	9
Gastropoda	1
Hemiptera	2
Hirudinea	1
Hydrozoa	1
Isopoda	2
Lepidoptera	2
Mecoptera	10
Megaloptera	8
Nematoda	3
Nemertea	3
Neuroptera	6
Nematomorpha	6
Notostraca	1
Odonata	3
Oligochaeta	2
Plecoptera	10
Porifera	4
Trichoptera	8
Turbellaria	2

Families	
Aeshnidae	4
Ameletopsidae	7
Amphisopidae	1
Ancylidae	4
Antipodoeciidae	8
Aphroteniinae	8
Athericidae	8
Atriplectididae	7
Atyidae	3
Austrocorduliidae	10
Austroperlidae	10
Baetidae	5
Belostomatidae	1
Bithyniidae	3
Blephariceridae	10
Branchipodidae	1
Caenidae	4
Calamoceratidae	7
Calocidae	9
Ceinidae	2
Ceratopogonidae	4
Chaoboridae	2
Chironominae	3
Cirolanidae	2
Clavidae	3
Coenagrionidae	2
Coloburiscidae	8
Conoesucidae	7
Corbiculidae	4
Corduliidae	5
Corixidae	2
Corophiidae	4
Corydalidae	7
Culicidae	1
Curculionidae	2
Diamesinae	6
Diphlebiidae	6
Dixidae	7
Dolichopodidae	3
Dugesiidae	2
Dytiscidae	2
Ecnomidae	4
Elmidae	7
Empididae	5
Ephydridae	2
Erpobdellidae	1
Eusiridae	7
Eustheniidae	10
Gelastocoridae	5
Gerridae	4
Glacidorbidae	5
Glossiphoniidae	1
Glossosomatidae	9
Gomphidae	5
Gordiida	5
Gripopterygidae	8
Gyrinidae	4
Haliplidae	2
Hebridae	3
Helicophidae	10
Helicopsychidae	8
Hemicorduliidae	5
Hydraenidae	3
Hydridae	2
Hydrobiidae	4
Hydrobiosidae	8

Hydrochidae	4	Noteridae	4	Richardsonianidae	4
Hydrometridae	3	Notonectidae	1	Sciomyzidae	2
Hydrophilidae	2	Notonemouridae	6	Scirtidae	6
Hydropsychidae	6	Odontoceridae	7	Sialidae	5
Hydroptilidae	4	Oeconesidae	8	Simuliidae	5
Hygrobiidae	1	Oniscidae	2	Siphlonuridae	10
Hymenosomatidae	3	Oniscigastridae	8	Sisyridae	3
Hyriidae	5	Ornithobdellidae	1	Sphaeriidae	5
Isostictidae	3	Orthocladiinae	4	Sphaeromatidae	1
Janiridae	3	Osmylidae	7	Spongillidae	3
Kokiriidae	3	Palaemonidae	4	Stratiomyidae	2
Koonungidae	1	Paracalliopidae	3	Synlestidae	7
Leptoceridae	6	Paramelitidae	4	Syrphidae	2
Leptophlebiidae	8	Parastacidae	4	Tabanidae	3
Lestidae	1	Philopotamidae	8	Talitridae	3
Libellulidae	4	Philorheithridae	8	Tanyderidae	6
Limnephilidae	8	Phreatoicidae	4	Tanypodinae	4
Lindeniidae	3	Physidae	1	Tasimiidae	8
Lymnaeidae	1	Planorbidae	2	Telephlebiidae	9
Macromiidae	8	Pleidae	2	Temnocephala	5
Megapodagrionidae	5	Podonominae	6	Thaumaleidae	7
Mesoveliidae	2	Polycentropodidae	7	Thiaridae	4
Muscidae	1	Pomatiopsidae	1	Tipulidae	5
Nannochoristidae	9	Protoneuridae	4	Urothemistidae	1
Naucoridae	2	Psephenidae	6	Veliidae	3
Neoniphargidae	4	Psychodidae	3	Viviparidae	4
Nepidae	3	Ptilodactylidae	10		
Neurorthidae	9	Pyralidae	3		

Family groups

Aeshnid-like dragonflies	5
Corduliid/libellulid dragonflies	5
Dolichopodidae, Tabanidae and Tipulidae	4
Ephydridae, Muscidae, Sciomyzidae and Syrphidae	2
Primitive dragonflies	10

Note: Scores modified from SIGNAL and SIGNAL 2, Bruce Chessman (1995, 2001)

Glossary

abdomen – posterior part of the body, behind the thorax (see p. 17)

adductor muscle – a muscle that pulls things together (see p. 46)

aestivate – to become dormant over summer, especially during dry periods

algae – simple, aquatic, plant-like organisms that can use sunlight and nutrients to produce their own energy

antenna (plural: antennae) – paired, long appendages attached to the head (see p. 17)

anterior – the front (see p. 17)

apex – the tip or end of something

apical – at the tip of a limb (from apex)

appendage – a part of an animal, like a leg or an antennae, that is attached to its main trunk but clearly separate

aquatic – found in water

arthropods – invertebrates with an external skeleton from the phylum Arthropoda (for example insects and crustaceans)

asexual reproduction – reproduction that does not need both males and females

atmospheric oxygen – oxygen that is part of gaseous air (the stuff we breath)

benthic – from the bed of a river or lake

benthic algae – algae that grows on the stream or lake bed

benthos – animals or plants that live in or on the stream or lake bed

bioassessment – assessing a river's health using the animals and plants that live in it

biomass – a measure of a quantity or mass of organisms

budding – asexual reproduction by dividing and forming multiple individuals from a single parent

carapace – hard cover over thorax, or more of the body in crustaceans

carina – a ridge

carnivore – an animal that eats other animals

catchment – the land from which water flows into a river

caudal filaments – tails, usually paired (see cerci)

cephalothorax – a body segment equivalent to a fused head and thorax

cerci – the outer two tails, particularly on mayflies and stoneflies (see p. 131)

chelae – pincer-like claws

chelate – bearing pincer-like claws

chitin – the main material that insects' external skeletons are made of

cilia (plural: ciliae) – microscopic hairs that occur in large quantities and are used to move small animals or their food

claspers – a pair of limbs used by a male to grasp the female, usually at the end of the abdomen

class – a taxonomic level (see p. 18)

classification – a system that separates plants and animals into groups such as: Class, Order, Family, Species, etc.

collectors – animals that feed on detritus that they collect either from water (filter feeders) or the surfaces around them

community – the different species that live in the same area and use the same resources

compound eye – an eye made from lots of smaller 'eyes'

convoluted – with a complicated, folded edge

coxa – a leg segment closest to the body

crochet – a circlet or arc of small hooks

described species – species that can be recognised from formal, scientifically published descriptions

detritivore – an animal that eats detritus

detritus – decomposing animal and plant matter, such as old leaves

dextral – coiled (particularly snails) so that the opening of the shell is on the right when viewed ventrally (see p. 46)

diatoms – small, single celled algae in glass-like cases

digitate – finger-like

dissolved oxygen – oxygen that is part of liquid water

distal – distant from the main body (for example the far end of an antenna, opposite to proximal)

dorsal – on or of the back or top (see p. 17)

dorso-ventrally flattened – flattened so that the back (dors) and front (venter) are closer, opposite to flattened from the sides

ecology – the study of the way animals and plants interact with each other and their physical surroundings

elytron (plural: elytra) – hardened front wings that cover and protect the hind wings (see p. 92)

emerge – to leave the water (usually as an adult insect after living within the stream as a larva or nymph)

endangered – in danger of becoming extinct

endemic – distribution restricted to a single geographic location

ephemeral – short lived

epi- – of the edge

epiphytic – growing on the surface of other plants

exopod – extra outer limb especially in primitive crustaceans

exoskeleton – an external skeleton or hardened skin

extant – still living, the opposite of extinct

extinct – no longer living (of a species)

family – a taxonomic level (see p. 18)

fauna – animals

femur (plural: femora) – a leg segment (see p. 161)

filamentous algae – algae that grow in long thin strings

filter feeders – animals that filter water for food particles

flagellum (plural: flagellae) – a whip-like process

flora – plants

fore trochantin – (see diagram on p. 191)

frontoclypeus – an hourglass-shaped head sclerite (see p. 191)

gemmule – see sponges p. 33

genus (plural: genera) – a taxonomic level (see p. 18)

gill – a plate-like or filamentous organ with a large surface area, used to extract oxygen from the water

gnathopods – the first two legs on amphipods, often with robust, chelate claws (see p. 68)

grazers – animals that feed on dense patches of plant, such as grass or periphyton

habitat – the physical space (and sometimes the chemical requirements) required by an organism to live

halteres – small, knob-shaped structures that replace wings on the metathorax of true flies (see p. 112)

head capsule – a hardened capsule that covers the head (see p. 112)

helicoid – spiralling, said about snail shells

herbivore – an animal that feeds on plants

hydrophilic – water loving

hydrophobic – water repellent

instar – stages of growth in animals that shed their external skeletons, each time the animal sheds it starts a new instar

invertebrate – an animal without a backbone or the small bones (vertebrae) from which it is built

kingdom – a taxonomic level (see p. 18)

labial palp – paired, hinged plates that form part of the dragonfly mouthparts (see p. 161)

labium – the mouthparts equivalent to a lower lip (see p. 191)

labrum – the mouthparts equivalent to an upper lip (see p. 191)

larva (plural: larvae) – a juvenile insect

lateral – on or of the sides (see p. 17)

laterally flattened – flattened from the sides

lentic – of still water such as ponds and lakes

littoral zone – a zone along the edge of a water body, often defined by high water marks

longitudinal – along the length of an object

lotic – of running/flowing water such as rivers and streams

macroinvertebrate – an invertebrate which is large enough to see without a microscope

macrophyte – a non-algal water plant

mandible – one of the more hardened mouthparts, often used for biting, or chewing

mantle – of gastropods, the layer of flesh closest to the shell (see p. 46)

marginal – near the edge of the water

marsupium – consists of appendages that cover eggs in some crustaceans

maxillary palps – one of the sets of mouthparts (paired) in many arthropods (see p. 92)

mentum – roughly equivalent to a chin, also a tooth plate in chironomids (see p. 112)

meso- – middle (see p. 17)

meta- – last (see p. 17)

monitoring – sampling repeatedly, to pick up changes that might occur over time

moult – to lose the outer layer of skin (verb), or the outer layer of skin that is lost (noun)

nektonic – a description of animals that swim freely in open water

notum (plural: nota) – dorsal part of a thoracic segment

nymph – a juvenile insect that closely resembles the adult, but has poorly developed wings

ocelli – simple eyes like those on larvae

omnivore – an animal that eats both plant and animal matter

operculum – a small round door used by gastropods to close their shells

order – a taxonomic level (see p. 18)

organism – a living thing (includes plants, animals, fungi, bacteria etc.)

palp – a small finger-like appendage, fleshy in molluscs and jointed in arthropods

peduncle – the base segment that rami are attached to in crustaceans (see p. 68)

pelagic – living in the middle or top of a water body rather than on its bed

periphyton – a layer of slime on rocks and other surfaces in the stream which is made up of algae, fungi and bacteria

phylum – a taxonomic level (see p. 18)

phytoplankton – microscopic plants that float free in water

pigmented – darkened or coloured

plankton – microscopic plants and animals that float free in water

plastron – a breathing organ consisting of a thin layer of hairs that trap air

pleon – the part of a crustacean body that the pleopods are attached to (see p. 68)

pleopods – the appendages on a crustacean behind the legs, usually for swimming (see p. 68)

pleotelson – the segment formed by the fusion of the pleon, and telson in phreatoicid isopods

post- – after

posterior – the hind end (see p. 17)

postmentum – especially in odonates, one of the mouthparts (see p. 161)

preapical – near, but not at the tip of a limb

predators – animals that hunt, kill and eat other animals

prehensile – adapted for grasping, like fingers

prementum – especially in odonates, one of the mouthparts (see p. 161)

pre- – before

pro- – first (see p. 17)

proboscis – the beak-like mouthparts of a true bug (Hemiptera, see p. 144)

processes – bits that stick out but aren't considered as separate limbs

pro-legs – simple, fleshy legs without proper joints

proximal – near the body (opposite of distal)

pubescent – hairy

pupa – the phase between larva and adult, usually non-moving and in a protective case

radula – a hard, file-like structure in molluscs (see pp. 46 and 49)

ramus (plural: rami) – the final segments of the uropod, usually paired on amphipods (see p. 68)

raptorial – designed for grasping, usually with large claws

rare – an animal with a small geographic distribution

reach – a section of river

riffle – a fast-moving, shallow section of river where the water surface is disturbed by the river bed

river health – a concept used to help explain the idea of river degradation

rostrum – see proboscis

sclerite – a hardened plate of external skeleton

sclerotised – hardened, leathery, often dark orange, brown or black

scraper – an animal that scrapes food from hard surfaces

scutellum – a small triangular plate bordered by the wings and the pronotum in beetles and bugs (see p. 92)

sessile – attached to a solid surface

seta (plural: setae) – stiff hairs

shredder – an animal that gets its food by pulling apart organic matter such as leaves

sinistral – coiled (particularly snails) so that the opening of the shell is on the left when viewed ventrally (see p. 46)

siphon – a hollow tube used by some true bugs to puncture the water surface while breathing

snags – fallen branches and logs that provide habitat within a river or pond

sp. – species (singular); usually indicates that the animal is unknown beyond genus level

species – a taxonomic level (see p. 18)

spiracle – a hole that connects the insides of an insect to a supply of air (see p. 112)

spp. – species (plural) indicates many species within a genus

sternum – ventral part of a body segment

swimming hairs – a fringe of hairs, (usually along a leg) that allow it to work like a paddle

tarsus (plural: tarsi) – the final segments of a leg after the tibia (see p. 161)

telson – the central piece of a crustacean tail fan, shield-shaped (see p. 68)

tergite – a sclerotised dorsal plate

terminal filament – the central tail (of three in mayflies)

terrestrial – found on land

thoracic – of the thorax

thorax – the body segments immediately after the head (see p. 17)

tibia – a leg segment (see p. 161)

trachea – microscopic tubes thoughout an insect's body that carry air to every cell

trophic levels – a more scientific name for the ecological 'jobs' described on page 7

tubercles – rounded lumps

uniramous – with a single ramus (see ramus)

uropod – the last three appendages on the underside of a crustacean (see p. 68)

ventral – on or of the underside (see p. 17)

ventral apotome – a small square sclerite on the underside of a caddis larva's head (see p. 191)

vulnerable – likely to become endangered under current conditions

water column – a term used to convey the idea of animals and plants moving vertically through the water

wing pads/buds – the covers on a nymph's back that house its developing wings

zooplankton – microscopic animals that float free in water

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